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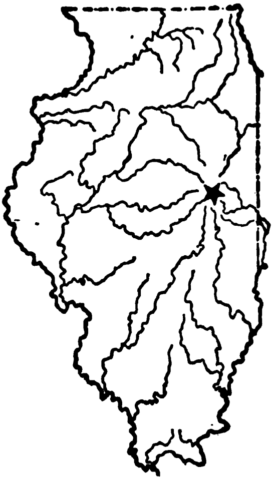
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 139

COMPOSITION OF MARKET BUTTER

By CARL E. LEE and JESSE M. BARNHART



URBANA, ILLINOIS, OCTOBER, 1909

2234-17/3

Summary of Bulletin No. 139

1. Average composition of 574 samples of market butter collected for a period of one year beginning March, 1907, was: Water 13.54 percent, fat 83.20 percent, salt 2.25 percent, and casein and ash, 0.9 percent.

2. There was no difference in composition of butter caused by the season of the year, the state where it was made, or the dealer by which it was handled.

3. The variation in composition of samples of butter taken from the various creameries was not greater than the samples taken from any single creamery.

4. Average composition of sixty samples of convention butter was: Water 12.54 percent, fat 84.65 percent, salt 1.77 percent, and casein and ash 1.02 percent.

SEP 23 1915

COMPOSITION OF MARKET BUTTER

BY

CARL E. LEE, ASSISTANT CHIEF DAIRY MANUFACTURES, AND
JESSE M. BARNHART, ASSISTANT CHEMIST

From observations of a general and specific nature it is perfectly evident there is no uniform method followed in making butter. The object then of this investigation was to study the composition of butter as it is found in the market, also to note the effect of variation in making upon fat, water, and salt content. This led to a study of the factors influencing composition of butter reported in Bulletin No. 137. Incident to this study samples of market butter were collected each month for a period of one year beginning March, 1907. With but one exception, these samples were taken indiscriminately and no attempt was made to always get them from the same factory. Samples collected in this manner were therefore quite representative of the butter in the markets of Elgin, Aurora, and Chicago during that time. Aside from the regular samples collected on the market a large number of samples were collected by our Creamery Field Instructor, F. A. Jorgensen. This butter was usually made under the instructor's supervision and the samples taken from the churn. In addition to this several samples were sent to the station by creamery operators for the purpose of securing coöperative information. The results of analyzing such samples are not all reported. Samples collected at the factory by the instructor or taken by the buttermaker may or may not be fair samples of market butter. If it had been known at any factory that samples were to be taken for analyses, the usual method of making might have been altered.

SAMPLING THE BUTTER

In sampling the butter in the 60 pound tub, a trier extending the full depth of the tub was removed and the top one to two inches of the plug replaced. All of the free water appearing on the surface of the butter removed, was collected with the samples. This is shown in Bulletin No. 137 to be an accurate method of sampling market butter.

TABLE 2—*Continued*

IOWA

Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein	Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein
79	4/27/7	12.78	82.56	....	....	557	10/ 6/7	13.14	85.05	1.13	.68
"	5/31/7	13.05	84.02	....	....	559	3/30/7	16.61	80.20	....	....
80	4/27/7	11.98	85.53	....	....	"	5/31/7	17.62	79.73	....	....
"	4/27/7	13.06	82.52	....	....	"	8/30/7	16.32	80.07	....	....
"	5/31/7	11.57	84.91	....	....	"	10/16/7	14.56	82.59	2.04	.81
87	9/20/7	13.13	84.09	2.07	.71	"	12/14/7	12.88	84.21	1.90	1.01
98	3/30/7	13.48	84.44	....	....	"	12/14/7	12.45	84.87	1.86	.82
"	6/27/7	11.95	85.69	....	....	"	12/14/7	12.83	84.39	1.98	.80
"	10/16/7	13.09	83.72	2.45	.74	"	12/14/7	14.25	82.57	2.11	1.07
"	2/24/8	12.84	84.09	2.76	.31	"	12/14/7	13.88	84.10	1.20	.82
99	10/16/7	13.86	81.92	3.45	.77	"	12/14/7	14.52	82.47	2.00	1.01
101	3/30/7	15.30	81.43	....	....	"	12/14/7	14.91	81.61	2.46	1.02
"	5/31/7	14.53	82.10	....	....	"	12/14/7	15.05	81.94	1.94	1.07
160	12/14/7	10.85	85.66	2.27	1.22	"	12/14/7	15.94	81.12	1.96	.98
321	3/20/7	15.14	81.13	....	....	"	12/14/7	14.95	81.95	2.09	1.05
"	9/20/7	14.29	82.61	2.32	.78	"	1/31/8	16.47	79.73	2.34	1.46
"	12/14/7	12.98	83.48	2.46	1.08	"	1/31/8	16.20	80.01	2.54	1.25
"	1/31/8	13.54	82.90	2.44	1.12	"	1/31/8	16.37	79.86	2.48	1.29
466	9/20/7	15.46	81.99	1.48	1.07	"	1/31/8	16.00	80.94	2.25	.81
"	11/ 7/7	14.12	83.33	1.71	.86	"	1/31/8	15.15	82.10	2.13	.62
469	9/20/7	14.58	81.47	2.86	1.09	"	1/31/8	15.20	81.88	2.26	.66
"	10/16/7	14.63	81.14	3.23	1.00	"	1/31/8	15.31	82.03	1.51	1.07
522	3/30/7	14.79	82.23	....	....	"	1/31/8	14.34	83.66	1.36	.64
"	8/30/7	14.31	83.27	....	....	"	1/31/8	14.84	82.50	1.60	1.06
"	9/20/7	15.43	82.33	1.43	.81	"	1/31/8	14.98	82.36	1.67	.99
"	10/16/7	16.34	80.71	2.32	.63	"	1/31/8	15.52	82.47	1.16	.85
"	1/31/8	15.05	81.69	2.61	.65	"	1/31/8	14.74	82.27	1.68	1.31
"	1/31/8	15.47	81.44	2.50	.59	"	1/31/8	15.56	82.47	1.21	.76
530	3/30/7	10.80	84.70	....	....	"	2/24/8	16.11	81.69	1.17	1.03
551	3/31/7	12.20	84.48	....	....	"	2/24/8	15.21	81.93	1.75	1.11
"	5/31/7	14.39	83.36	....	....	"	2/24/8	16.02	80.73	2.10	1.15
557	3/30/7	15.24	80.93	....	....	"	2/24/8	17.05	79.13	2.50	1.32
"	10/16/7	14.44	83.34	1.53	.69	772	3/30/7	11.65	85.88	....	....

IOWA—*Continued*

Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein	Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein
772	8/30/8	12.23	84.60	....	....	1128	6/27/7	12.54	85.73	....	....
"	9/20/7	12.97	84.48	1.95	.60	"	2/24/7	11.84	85.85	1.30	1.01
789	6/27/7	12.64	82.24	....	....	1158	4/27/7	12.86	82.99	....	....
"	7/24/7	13.49	81.76	....	....	1178	8/30/8	13.07	84.32	....	....
793	1/31/8	13.97	81.38	3.79	.86	"	9/20/7	13.27	83.43	2.77	.53
917	3/30/7	13.62	83.53	....	....	"	1/31/8	13.54	83.13	2.34	.73
"	5/31/8	13.13	83.61	....	....	1182	3/30/7	12.61	83.48	....	....
"	6/27/7	12.70	83.93	....	....	"	7/24/7	12.59	85.86	....	....
"	7/24/7	12.99	83.87	....	....	"	10/16/7	14.82	82.63	1.91	.64
"	9/20/7	12.26	84.69	2.31	.74	1183	3/30/7	13.69	84.45	....	....
"	10/16/7	13.22	83.67	2.49	.62	1189	2/24/8	14.75	82.89	1.43	.93
"	11/ 7/7	15.19	81.22	2.81	.78	1197	10/16/7	14.46	83.24	1.65	.65
945	4/27/7	12.10	85.54	....	....	1328	3/30/7	16.13	80.80	....	....
"	2/24/7	11.96	86.27	.82	.95	1333	3/30/7	14.63	82.54	....	....
999	2/24/7	12.27	84.50	2.16	1.07	1335	3/30/7	13.76	83.34	....	....
1017	3/30/7	14.02	81.91	....	....	"	7/24/7	13.67	82.77	....	....
"	5/31/7	13.53	82.96	....	....	"	9/20/7	14.41	82.30	2.52	.77
1024	8/30/7	16.59	81.58	....	....	"	1/31/8	14.25	82.97	2.03	.75
"	8/30/7	17.61	81.26	....	....	1405	4/27/7	11.73	84.61	....	....
"	10/16/7	16.52	81.48	1.92	1.08	"	5/31/7	11.86	84.37	....	....
"	2/24/8	13.23	84.25	1.54	.98	"	2/24/8	13.12	84.43	1.90	.55
1033	9/20/7	13.41	84.73	1.38	.48						

MINNESOTA

Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein	Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein
139	6/27/7	13.14	84.26	....	....	339	10/16/7	13.50	84.77	1.21	.52
"	9/20/7	12.62	85.17	1.98	.23	"	2/24/7	12.59	84.70	1.70	1.01
281	4/27/7	14.67	82.22	....	....	"	9/30/7	12.62	85.17	1.98	.23
"	9/20/7	12.53	84.54	2.16	.77	342	9/20/7	13.87	83.83	1.82	.49
"	2/24/7	14.15	83.14	1.52	1.19	"	10/16/7	13.73	83.67	1.66	.94
308	10/16/7	6.40	89.34	1.95	2.31	"	7/24/7	14.17	83.30	....	....
"	11/ 7/7	13.01	84.59	1.53	.87	343	9/20/7	13.50	84.15	1.71	.64
339	7/24/7	14.17	83.30	....	....	357	4/27/7	12.76	84.28	....	....

MINNESOTA—*Continued*

Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein	Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein
364	9/20/7	12.10	84.53	2.52	.85	587	4/27/7	12.61	84.52	....	....
"	10/16/7	12.60	84.38	1.82	1.20	"	12/14/7	12.24	84.27	2.36	1.13
"	11/ 7/7	10.98	86.39	1.89	.74	"	2/24/7	12.06	84.42	2.58	.94
365	9/20/7	12.52	84.78	2.09	.61	612	12/14/7	14.41	81.66	3.28	.65
374	11/ 7/7	12.43	83.53	2.87	1.17	629	9/20/7	13.63	82.28	3.36	.73
"	11/ 7/7	13.11	82.10	3.67	1.12	636	2/24/7	13.43	83.81	1.60	1.16
375	10/16/7	14.43	82.22	2.50	.85	638	2/24/7	14.94	80.50	3.44	1.12
"	2/24/7	14.31	83.17	1.72	.80	648	3/30/7	11.07	85.18	....	....
377	3/30/7	12.38	84.37	....	....	685	9/20/7	13.56	82.97	2.81	.66
"	6/27/7	11.34	85.09	....	....	689	5/31/8	13.21	83.18	....	....
"	10/10/7	12.62	84.20	2.25	.93	"	8/30/7	13.13	84.34	....	....
383	9/20/7	14.63	81.86	2.68	....	"	12/14/7	12.35	84.23	2.53	.89
"	2/24/7	12.77	84.52	1.86	.94	"	2/24/7	12.37	85.12	1.47	1.04
396	9/20/7	11.84	83.82	3.50	.64	726	4/27/7	13.89	83.28	....	....
397	5/31/7	14.25	83.63	....	....	"	8/30/7	12.07	84.39	....	....
"	8/30/8	12.83	83.59	....	....	"	10/16/7	12.43	84.62	2.28	.67
"	9/20/7	14.89	82.38	1.90	.83	"	11/ 7/7	13.09	83.13	2.92	.86
"	10/10/7	16.49	80.11	2.51	.89	736	7/24/7	11.70	86.03	....	....
"	11/ 7/7	14.87	82.12	2.55	.46	"	9/20/7	13.54	82.58	3.22	.66
"	2/24/7	13.86	83.44	1.73	.97	742	9/20/7	10.86	85.18	3.19	.77
496	2/24/7	11.73	85.16	1.88	1.23	783	3/30/7	13.11	81.73	....	....
499	7/24/7	12.40	85.29	....	....	"	5/31/7	13.10	83.71	....	....
"	10/ 7/7	13.16	83.56	2.24	1.04	"	10/16/7	13.23	83.61	2.49	.67
530	8/30/7	14.84	80.86	....	....	784	8/30/7	10.53	86.28	....	....
577	8/30/7	12.38	85.14	....	....	805	4/27/7	12.34	84.70	....	....
579	4/27/7	13.39	81.34	....	.92	"	12/14/7	13.31	83.28	2.20	1.21
"	9/20/7	13.86	82.95	2.27	....	807	9/20/7	12.07	84.64	2.55	.74
583	7/24/7	13.63	83.41	....	....	"	10/16/7	12.94	84.42	1.95	.69
586	4/27/7	14.01	83.99	....	....	839	6/27/7	13.44	83.59	....	....
"	8/30/7	17.65	79.44	....	....	856	10/16/7	13.01	84.84	1.79	.36
"	8/30/7	13.16	84.58	....	....	"	11/ 7/7	11.89	86.01	1.30	.80
"	12/14/7	12.57	85.19	1.20	1.04	"	2/24/7	13.89	83.03	2.28	.80
"	2/24/7	13.95	83.59	1.30	1.16	859	6/27/7	14.61	82.82	....	....

MINNESOTA—*Continued*

Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein	Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein
859	10/16/7	13.42	83.84	2.18	.56	1147	3/30/7	12.05	84.09	....	....
"	11/ 7/7	12.20	85.18	2.25	.37	"	4/27/7	13.57	83.98	....	....
939	4/27/7	13.41	82.41	....	....	1153	2/24/8	12.29	84.78	1.94	.99
"	10/16/7	14.75	81.84	2.51	.90	1161	4/27/7	12.14	84.50	....	....
940	3/30/7	14.09	81.61	....	....	"	4/24/8	13.38	83.72	1.78	1.12
941	3/30/7	12.99	83.39	....	....	1177	2/24/8	14.18	82.14	2.61	1.07
948	12/14/7	13.53	84.52	1.08	.87	1188	4/27/7	12.69	84.03	....	....
949	4/27/7	13.22	82.51	....	....	"	9/20/7	12.41	85.26	1.49	.84
"	2/24/8	12.46	82.42	4.14	.98	"	11/ 7/7	14.73	81.87	2.61	.79
952	2/24/8	11.73	84.36	3.03	.88	1190	2/24/8	14.19	83.98	.52	1.31
961	12/10/7	10.52	86.86	1.72	.90	1253	3/30/7	13.42	83.58	....	....
"	2/24/7	15.72	81.60	1.35	1.33	1257	12/14/7	12.70	84.96	1.31	1.03
1025	9/20/7	13.27	84.93	1.26	.54	1259	9/20/7	12.87	84.29	2.38	.46
1030	8/30/7	12.41	84.47	....	....	"	11/ 7/7	11.63	84.35	2.99	1.03
"	9/20/7	12.46	85.09	1.59	.86	"	12/14/7	13.69	83.10	2.21	1.00
"	11/ 7/7	12.02	84.56	2.52	.90	"	1/31/8	13.48	82.33	3.82	.37
1057	8/30/7	14.26	81.96	....	....	1275	4/27/7	12.48	82.43	....	....
"	9/20/7	11.70	84.23	3.29	.78	1276	2/24/8	10.70	86.83	1.61	.86
"	11/ 7/7	13.62	83.37	2.00	1.01	1281	3/30/7	13.38	82.23	....	....
1088	9/20/7	11.81	85.01	2.03	1.15	1336	11/ 7/7	13.53	83.35	2.23	.89
1102	4/27/7	14.56	83.47	....	....	1337	3/30/7	15.40	81.06	....	....
"	12/14/7	12.61	85.11	1.62	.66	"	2/24/8	14.16	82.06	2.66	1.12
"	2/24/7	13.77	82.08	3.08	1.07	1339	3/30/7	12.01	84.88	....	....
1105	2/17/7	10.30	86.18	2.73	.79	1346	2/24/8	12.44	84.20	2.20	1.16
"	12/14/7	12.64	83.32	3.07	.97						

WISCONSIN

Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein	Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein
44	7/24/7	12.15	85.49	....	....	48	5/31/7	10.49	86.78	....	....
"	11/ 7/7	13.56	83.49	1.64	1.31	50	10/16/7	13.89	81.64	3.64	.83
"	12/14/7	12.87	84.39	1.60	1.14	"	2/24/7	12.98	83.71	2.25	1.06
"	11/ 7/7	13.56	83.49	1.64	1.31	53	1/31/8	20.73	76.42	1.81	.84
48	4/27/7	11.98	85.58	....	....	58	8/30/8	12.84	83.11	....	....

WISCONSIN—*Continued*

Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein	Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein
63	5/31/7	12.24	83.60	....	....	156	11/ 7/7	14.32	81.88	2.73	1.07
"	2/24/8	13.65	82.68	2.34	1.33	157	11/ 7/7	13.89	80.73	4.23	1.15
64	3/30/7	13.15	84.32	....	....	"	11/ 7/7	11.46	84.13	3.50	.91
"	4/27/7	17.72	77.92	....	....	158	9/20/7	15.36	82.54	1.43	.67
"	10/16/7	15.48	80.66	2.84	1.02	"	11/ 7/7	12.94	84.28	1.95	.83
"	11/ 7/7	17.74	79.21	2.03	1.02	"	2/24/7	12.93	83.82	2.16	1.09
"	2/24/7	14.68	81.06	2.91	1.35	"	2/24/7	12.94	83.73	2.24	1.09
68	6/27/7	12.01	86.06	....	....	159	10/26/7	14.54	82.74	1.86	.86
68	7/24/7	13.19	84.83	....	....	166	5/31/7	10.94	84.91	....	....
69	5/31/7	11.69	85.47	....	....	"	6/27/7	13.68	83.52	....	....
"	1/31/8	13.80	83.58	1.61	1.01	"	9/20/7	10.28	87.25	1.93	.54
70	9/20/7	13.56	83.27	2.30	.87	"	1/31/8	12.63	82.34	3.87	1.16
74	3/30/7	14.16	81.57	....	....	172	8/30/7	12.76	84.70	....	....
"	4/27/7	11.87	83.24	....	....	173	5/31/8	14.65	81.78	....	....
82	4/27/7	12.17	85.61	....	....	"	5/31/7	15.06	81.70	....	....
93	7/24/7	15.28	79.75	....	....	180	8/30/7	15.70	82.15	....	....
111	5/31/7	.....	.....	....	....	181	8/30/8	15.11	82.07	....	....
120	7/24/7	13.51	84.11	....	....	183	8/30/7	11.96	83.57	....	....
121	1/31/7	14.38	80.78	3.65	1.19	"	1/30/8	11.67	84.26	3.01	1.06
126	3/30/7	11.83	83.65	....	....	186	8/30/7	12.34	84.57	....	....
"	6/27/7	13.18	84.94	....	....	"	11/ 7/7	12.67	85.43	1.35	.55
"	7/24/7	13.91	83.61	....	....	193	7/24/7	12.54	83.46	....	....
"	9/20/7	13.09	84.46	1.95	.50	194	7/24/7	11.28	86.56	....	....
"	10/16/7	14.27	83.50	1.69	.54	"	10/16/7	13.42	84.05	1.63	.90
135	5/31/7	12.71	84.74	....	....	"	11/ 7/7	13.22	83.30	2.56	.92
"	6/27/7	9.88	84.20	....	....	253	2/24/8	13.28	83.00	2.64	1.08
"	8/30/7	12.80	84.68	....	....	264	10/16/7	12.75	83.87	2.58	.80
"	9/20/7	14.05	83.63	1.89	.43	293	5/31/7	14.74	82.54	....	....
"	1/31/8	13.09	84.13	1.63	1.15	"	1/31/8	13.78	83.75	1.46	1.01
147	1/31/8	12.80	83.52	2.51	1.17	"	1/31/8	11.36	86.18	1.27	1.19
156	8/30/8	13.10	84.29	....	....	362	4/27/7	12.52	85.03	....	....
"	9/20/7	12.89	84.13	2.09	.89	"	8/30/7	13.16	84.56	....	....
"	11/ 7/7	14.30	81.96	2.77	.97	"	9/20/7	13.49	84.04	1.96	.51

WISCONSIN—*Continued*

Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein	Factory No.	Date collected	Per cent water	Per cent fat	Per cent salt	Per cent casein
362	2/24/8	13.42	84.27	1.58	.73	1060	8/30/7	14.82	82.03	....	....
695	4/27/7	12.14	84.46	....	....	"	9/20/7	14.18	83.24	1.49	1.09
"	12/14/7	12.48	84.48	2.41	.63	"	10/16/7	14.55	83.38	1.39	.68
769	4/27/7	13.21	82.64	....	....	1068	4/27/7	12.47	84.27	....	....
"	7/24/7	12.71	83.09	....	....	"	5/31/7	13.31	82.09	....	....
"	12/14/7	12.66	83.95	2.24	1.15	"	8/30/7	12.97	83.31	....	....
"	2/24/8	13.94	81.82	2.85	1.39	"	9/20/7	12.79	83.96	....	....
831	4/27/7	11.68	86.09	....	....	1097	4/27/7	12.66	82.94	....	....
"	8/30/7	11.24	86.78	....	....	1165	6/27/7	12.95	84.00	....	....
874	5/31/7	13.43	83.75	....	....	1186	8/30/7	12.59	85.86	....	....
"	8/30/7	13.97	83.83	....	....	"	1/31/8	14.86	81.97	1.91	1.26
"	9/20/7	11.38	84.59	3.14	.89	"	2/24/8	13.80	82.89	2.33	.98
883	4/27/7	13.19	82.49	....	....	"	2/24/8	13.41	81.20	4.12	1.27
889	4/27/7	13.05	82.52	....	....						
LOCATION UNKNOWN											
56	6/27/7	11.46	84.65	....	....	174	6/27/7	11.95	85.69	....	....
59	6/27/7	12.05	84.62	....	....	198	10/16/7	13.50	83.18	2.59	.73
70	6/27/7	12.42	84.89	....	....	628	10/16/7	12.99	84.70	1.43	.82
77	5/31/7	12.64	83.96	....	....	777	5/31/7	12.00	84.38	....	....
107	10/16/7	15.04	80.72	2.97	1.27	784	6/27/7	11.21	86.03	....	....
153	6/27/7	12.42	85.84	....	....	788	10/16/8	14.43	82.22	2.41	.94
174	6/27/7	12.26	85.47	....	....	871	6/27/7	12.07	84.77	....	....
"	8/30/7	14.63	82.39	....	....						

TABLE 3. SUMMARY OF TABLE 2.

	Illinois	Wisconsin	Minnesota	Iowa	Location unknown
Number of samples.....	65	103	131	109	15
Average percent water ..	13.67	13.28	13.05	14.17	12.73
Highest " " ..	19.03	20.83	17.65	17.62	15.04
Lowest " " ..	11.22	9.88	6.40	10.80	11.21
Number of samples.....	65	103	131	109	15
Average percent fat.....	83.04	83.49	83.78	82.91	84.23
Highest " "	86.41	87.25	89.34	86.27	86.03
Lowest " "	77.23	76.42	79.44	79.13	80.72
Number of samples.....	25	50	84	65	4
Average percent salt....	2.35	2.29	2.23	2.05	2.35
Highest " "	4.46	4.23	3.82	3.79	2.97
Lowest " "	0.80	1.39	0.52	0.82	1.43
Number of samples.....	25	50	84	65	4
Average casein and ash .	0.88	0.96	0.86	0.88	0.94
Highest " " " ..	1.48	1.39	2.31	1.46	1.27
Lowest " " " ..	0.61	0.43	0.23	0.31	0.73

TABLE 4. DISTRIBUTION OF SAMPLES ON A UNIT SCALE WITH REFERENCE TO WATER AND FAT CONTENT

No. of samples for each division	Percent water	Percent, total number of samples	No. of samples for each division	Percent fat	Percent, total number of samples
1	6 to 7	0.23	1	76 to 77	0.23
...	7 to 8	0.00	3	77 to 78	0.70
...	8 to 9	0.00	1	78 to 79	0.23
1	9 to 10	0.23	11	79 to 80	2.57
12	10 to 11	2.80	15	80 to 81	3.50
36	11 to 12	8.41	50	81 to 82	11.68
116	12 to 13	27.10	78	82 to 83	18.22
133	13 to 14	31.07	100	83 to 84	23.36
77	14 to 15	17.99	110	84 to 85	25.70
27	15 to 16	6.30	40	85 to 86	9.34
14	16 to 17	3.27	17	86 to 87	3.97
8	17 to 18	1.86	1	87 to 88	0.23
1	18 to 19	0.23	1	88 to 89	0.23
1	19 to 20	0.23			
1	20 to 21	0.23			

Salt determination was made of all the samples collected the last six months. The average salt content of the 231 samples was 2.2 percent, highest 4.46 and lowest 0.52 percent. The average casein and ash content was 0.39 percent.

ILLINOIS FACTORY NO. 129

Samples were collected from this factory six different times. On July 24, 1907, samples were taken from three different tubs, representing three different days' make. One of these tubs contained 14.56 percent of water, which was the highest of all samples collected from this factory. Another of these samples contained only 11.90 percent water. Only one other sample from this factory contained a lower percent of water and it was collected May 31.

ILLINOIS FACTORY NO. 1028

In all, 13 samples were collected representing six different months' make. Highest water content 17.08 percent was found in a sample obtained October 16, two other tubs sampled on that same day contained 16.43 and 15.28 percent water respectively. Lowest water content of all samples was 12.23 percent for January 31, 1908. There was also a marked variation in the salt content of the butter from this factory. October 16, 1907, 4.46 percent salt was found and on February 24, 1908, 1.63 percent. Two samples representing different days' make varied 1.85 percent in salt.

ILLINOIS FACTORY NO. 1150

This factory is represented by eleven samples for six different months. The water content in the butter from this factory was very uniform. Highest was 14.42, lowest 13.03 percent. Average 13.82. The same degree of variation would have been found had all the samples been collected from the same or different tubs of butter representing the same days' make.

IOWA FACTORY NO. 559

In all 31 samples were collected representing seven different months. The first sample was collected March 30, 1907, and contained 16.61 percent water. Samples collected May 31, contained 17.62 percent water, and August 30, 16.32 percent water. Samples collected October 16 contained 14.56 percent water. December 14, ten samples were collected from ten different tubs representing four days' make. Analyses gave the following results.

TABLE 5. ONE WEEK'S MAKE, IOWA FACTORY NO. 559

Date when butter was made	Percent			
	Water	Fat	Salt	Casein
December 5, 1907	12.88	84.21	1.90	1.01
" " "	12.45	84.87	1.86	0.82
" " "	12.83	84.39	1.98	0.80
" 7 "	14.25	82.57	2.11	1.07
" " "	13.88	84.10	1.20	0.82
" " "	14.52	82.47	2.00	1.01
" 9 "	14.91	81.61	2.46	1.02
" 11 "	15.05	81.94	1.94	1.07
" " "	15.94	81.12	1.96	0.98
" " "	14.95	81.95	2.09	1.05
Average............	14.18	82.92	1.95	0.95

The butter made December 11, contained an average of 2.59 percent more water than the butter made December 5. January 31, 1908, 13 samples representing one week's make were again obtained from this factory's butter. Three of these samples representing one day's make contained over 16 percent water while the butter for the other three days with but one exception contained less than 16 percent water. February 24, 1908, only four samples were collected from tubs marked 2-13; 2-15; 2-17; and 2-19, containing 16.11; 15.21; 16.02 and 17.05 percent water respectively. It is evident that the buttermaker in this factory was intentionally making butter with high water content. After the first few samples had been analyzed, the firm buying the butter notified the creamery company regarding the condition of the butter. Only two other Iowa factories made butter that contained over 16 percent water.

MINNESOTA BUTTER

Samples of butter were collected from 70 different creameries. Out of this number only two creameries made butter containing over 16 percent water. One of these factories No. 397 from which 7 different samples were collected, exceeded the 16 percent limit in October. The other factory No. 586 which was responsible for the other sample above legal limit contained 17.65 percent water. Another sample collected the same day from this factory contained only 13.16 percent water. Apparently these two lots of Minnesota butter with high water content were not representative of the butter from these two creameries.

WISCONSIN BUTTER

Of the one hundred and four samples representing 47 different creameries only three samples contained over 16 percent water. One sample was collected from factory No. 53 on January 31, 1908. Its composition was as follows: Water 20.73, fat 76.42, salt 1.81 percent. Five samples were collected from factory 64; two of these samples contained 17.72 and 17.74 percent water respectively.

One hundred and forty samples of butter and 8 samples of Process butter were collected from four other commission firms. The following table gives the highest, lowest and average water, fat, salt, casein, and ash content by states for each dealer.

TABLE 6. COMPOSITION, HIGHEST, LOWEST, AND AVERAGE

Location by states	No. of samples	Percent water			Percent fat			Percent salt			Percent casein and ash		
		Highest	Lowest	Av.	Highest	Lowest	Av.	Highest	Lowest	Av.	Highest	Lowest	Av.
Dealer No. 1													
Wis.	23	17.01	10.80	13.44	85.97	80.00	83.29	.....	.....	.....	.....	.....	.....
	13	.....	.....	.....	.....	.....	.....	3.74	1.40	2.36	1.47	0.22	0.86
Mich.	6	14.46	11.88	12.73	85.23	81.94	83.85	.....	.....	.....	.....	.....	.....
Mo.	2	14.77	13.47	14.12	82.36	81.06	81.71	.....	.....	.....	.....	.....	.....
Ind.	7	16.67	11.64	14.38	85.45	77.69	81.67	.....	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....	.....	2.37	1.96	2.16	1.15	0.83	0.99
Ill.	11	15.03	12.37	13.84	83.99	79.14	81.86	.....	.....	.....	.....	.....	.....
	5	.....	.....	.....	.....	.....	.....	4.83	0.26	3.50	1.16	0.74	0.93
Minn.	5	15.18	13.69	13.92	85.03	80.35	82.70	.....	.....	.....	.....	.....	.....
	3	.....	.....	.....	.....	.....	.....	3.94	1.44	2.56	1.27	0.97	1.14
Iowa	8	16.22	12.76	14.21	84.57	80.99	82.78	.....	.....	.....	.....	.....	.....
	5	.....	.....	.....	.....	.....	.....	2.70	1.36	2.07	1.00	0.84	0.94
Neb.	1	13.58	.....	.....	82.82	.....	.....	2.47	.....	.....	1.13	.....	.....
Miscl.	17	16.57	10.51	13.87	86.08	78.14	82.66	.....	.....	.....	.....	.....	.....
	11	.....	.....	.....	.....	.....	.....	3.55	1.42	2.40	1.31	0.80	0.85
Dealer No. 2													
Ill.	22	15.96	11.17	13.58	85.71	78.15	82.92	.....	.....	.....	.....	.....	.....
	4	.....	.....	.....	.....	.....	.....	2.97	2.17	2.63	1.10	0.85	0.96
Iowa	13	14.82	11.17	13.30	84.47	80.80	82.82	.....	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....	.....	2.69	1.95	2.32	1.02	0.54	0.78
Dealer No. 3													
Ill.	2	12.90	12.50	12.70	84.66	84.29	84.47	2.27	1.79	2.03	0.94	0.65	0.79
Iowa	4	15.55	12.51	13.64	85.40	80.87	83.78	2.91	1.05	1.83	1.04	0.46	0.73
Neb.	2	13.07	12.27	12.67	84.75	84.35	84.55	2.57	1.41	1.99	0.81	0.77	0.79
Minn.	2	12.13	11.94	12.03	84.49	84.46	84.47	3.04	1.90	2.47	1.48	0.53	1.00
Wis	2	16.51	13.43	14.97	84.45	81.10	82.77	1.88	1.67	1.77	0.72	0.24	0.48
Dealer No. 4													
	13	18.84	11.84	13.74	86.37	78.10	82.92	3.51	1.10	2.19	1.43	0.69	1.07

TABLE 7. COMPOSITION OF ALL THE SAMPLES OF PROCESS BUTTER

Date collected	Percent			
	Water	Fat	Salt	Casein and ash
April 27, 1907	16.48	78.31	....	....
May 31, 1907	18.40	76.51	....	....
June 27, 1907	14.68	80.95	....	....
July 24, 1907	16.31	80.32	....	....
Oct. 16, 1907	16.23	79.07	2.32	1.38
Oct. 16, 1907	16.14	79.37	3.13	1.36
Nov. 7, 1907	15.57	79.74	3.76	0.83
Dec. 14, 1907	16.09	80.05	2.77	1.10

The above Table needs no explanation.

All of the samples collected from Dealer No. 2 were obtained from butter made in his own creameries, located in Illinois and Iowa, and in no case was there a sample containing over 16 percent water. A total of twelve such samples were obtained from the other three commission firms.

There was apparently no difference in the average composition of butter made in different states and handled by the various firms. The existing variation is no greater than would naturally be present in collecting a large number of samples from several different places. Two samples of butter taken from the same package, will vary as much as one percent in water content, so, if a buttermaker should select ten tubs representing one day's make for water determination and one sample is taken from each tub the results would not be identical. This is due to a variation in sampling rather than to an error in making the moisture test. Every buttermaker should aim to make butter safely within the legal limit. This can be accomplished by handling the cream and butter in such a manner that there is the proper degree of firmness and body in the finished product.

When the butter is in the granular state and the buttermilk has been drawn, one can readily tell what changes, if any, must be made in the subsequent handling of that butter to produce desired results. One who is familiar with conditions in his factory where approximately the same grade, of milk and cream is received from day to day, need never make butter that is doubtful. Furthermore, if butter of a certain composition is desired, it need vary from this content only so far as one sample from the same source varies from another.

Uniformity may even be secured for a definite length of time by following set rules. For example, a student who had never operated a creamery but followed instructions in operating the churn in the University creamery for a period of two months, made during that time butter of uniform composition from day to day. Another man in the same position, who was not particular to follow a fixed standard, obtained results that were in accordance with the degree of variation in the method of operation. The field instructor secured samples of butter from various creameries where the same method of making was practiced with uniform results. After correcting the method of operation the following results in water content were obtained by a creamery that, previous to the visit of the instructor, had been making butter that would not pass inspection.

Date butter was made 1908	Per-cent water	Date butter was made	Per-cent water	Date butter was made	Per-cent wat'r	Date butter was made	Per-cent wat'r
June 14, tub 1	14.38	June 16, tub 3	14.94	June 18, tub 1	15.26	June 20, tub 1	14.93
June 14, tub 2	15.47	June 16, tub 4	14.30	June 18, tub 2	19.58	June 20, tub 2	15.32
June 16, tub 1	14.38	June 17, tub 1	14.58	June 19, tub 1	14.60	June 21, tub 1	15.04
June 16, tub 2	14.42	June 17, tub 2	14.64	June 19, tub 2	14.38	June 21, tub 2	15.70

Ten months later 10 samples of butter were received from this same creamery. Composition was as follows:

Date butter was made 1909	Percent			Date butter was made	Percent		
	Water	Fat	Salt		Water	Fat	Salt
April 17,..	14.75	81.95	2.40	April 24, 1909....	14.87	81.73	2.53
April 19,..	11.87	85.74	1.52	April 27, 1909....	14.34	82.91	2.01
April 20,..	13.12	83.63	2.48	April 24, 1909 (2)	14.86	81.74	2.69
April 21,..	13.42	82.53	3.42	April 28, 1909....	14.37	81.83	3.06
April 22,..	13.65	83.13	2.46	April 30, 1909....	12.45	85.25	1.63

On June 18, 1908, two samples were taken, one containing 15.26 percent water and the other 19.58. Other than this the water content in the first lot was very uniform. The composition of the second lot of samples was not as uniform as would be expected. On two succeeding days there was a difference of 1.43 percent in salt content.

The following samples were taken by Mr. Jorgensen, representing the butter made on the regular churning days in a southern Illinois creamery:

Churning number	Percent		
	Water	Fat	Salt
65	15.02	82.11	1.78
66	14.93	81.53	2.57
67	14.12	83.35	1.38
68	14.08	82.85	2.11
69	14.93	82.43	1.82
70	12.95	83.88	2.36
71	14.04	82.57	2.38
72	14.46	82.92	1.56
73	14.12	82.19	2.54
74	14.41	82.01	2.38
75	15.56	81.91	1.43

The above Table is a fair example of what one might expect when the details of operation are under the control of the operator.

At the National Creamery Buttermakers' Convention held in St. Paul, Minn., March, 1908, 502 tubs of butter were entered. Samples were obtained for analysis from 60 of these tubs, 39 of which had received a score of 93 and better.

TABLE 8. SCORE AND COMPOSITION OF CONVENTION BUTTER

Entry	Score	Percent			
		Water	Fat	Salt	Casein and ash
376	98	11.28	86.58	1.27	0.87
302	97½	14.50	83.26	1.36	0.88
233	96	11.39	86.28	1.16	1.17
344	96	12.20	84.88	1.93	0.99
421	96	13.74	83.99	1.22	1.05
327	95	12.34	84.25	2.26	1.15
419	95	13.36	84.29	1.45	0.90
397	95	12.77	84.63	1.55	1.05
426	94½	12.09	84.73	2.18	1.00
492	94½	12.40	85.84	0.98	0.78
139	94½	13.35	83.11	2.35	1.19
34	94	11.10	86.64	1.44	0.82
51	94	12.26	85.54	1.15	1.05
68	94	12.66	84.61	1.72	1.01
126	94	12.11	84.76	2.00	1.03
176	94	12.17	85.42	1.43	0.98
223	94	13.47	84.30	1.24	0.99
253	94	12.78	85.12	1.18	0.92
393	94	11.09	86.15	1.71	1.05
451	94	9.69	88.09	1.43	0.79
491	94	12.36	85.58	0.98	1.08
65	93½	12.94	85.07	1.03	0.96
103	93½	12.68	83.82	2.36	1.14
109	93½	11.74	84.79	2.22	1.25
225	93½	12.86	84.83	1.38	0.93
278	93½	12.61	85.05	1.44	0.90
301	93½	11.31	85.53	2.16	1.00
317	93½	12.97	84.68	1.48	0.87
328	93½	13.02	84.20	1.71	1.07
464	93½	12.01	84.83	2.15	0.91
358	93	13.16	84.41	1.37	1.06
487	93	12.65	85.21	1.20	.94
54	93	13.22	84.71	1.21	.86
146	92	12.63	84.74	1.44	1.19
462	91	11.81	85.25	2.12	0.82
86	90½	13.35	83.17	2.22	1.26
452	90½	13.96	83.01	1.91	1.12
179	90	13.64	82.22	3.09	1.05
258	90	13.33	83.69	1.77	1.21
260	90	11.68	85.85	1.24	1.23
378	90	12.33	85.19	1.75	0.72
450	90	14.39	81.87	2.83	0.91
76	89½	11.40	86.07	1.14	1.39
164	89	12.44	84.85	1.92	0.79
259	89	10.52	86.90	1.86	0.72
279	89	12.87	85.05	0.95	1.13
406	89	12.43	86.03	0.84	0.70
437	89	12.97	84.26	1.86	0.91
322	89	12.03	81.94	4.90	1.13
475	89	12.16	83.33	3.39	1.12
479	89	12.64	85.91	0.89	0.56
116	88½	12.30	85.57	1.11	1.02
43	88	11.96	85.19	2.05	0.80
119	88	13.62	84.06	0.96	1.36
205	88	14.33	81.44	3.05	1.18

TABLE 8—*Continued*

Entry	Score	Percent			
		Water	Fat	Salt	Casein and ash
214	88	14.10	83.12	1.79	0.99
355	88	11.60	84.60	2.78	1.02
178	87	12.85	82.67	3.02	1.46
251	87	13.39	83.30	2.44	0.87
306	87	11.88	85.91	1.33	0.88
Average....		12.54	84.37	1.77	1.02
Highest		14.50	88.09	4.90	....
Lowest.....		9.69	81.44	0.84	....

Only 8⅓ percent of the tubs analyzed contained less than 83 percent of fat.

TABLE 9. COMPARISONS OF SCORE AND COMPOSITION

No. of tubs in each average	Score	Percent			
		Water	Fat	Salt	Casein
5	96, 97½ and 98	12.62	85.00	1.39	0.99
3	95	12.82	84.39	1.75	1.04
13	94, 94½	12.12	85.37	1.52	0.99
12	93, 93½	12.58	84.77	1.65	1.00
1	92	12.63	84.74	1.44	1.19
1	91	11.81	85.25	2.12	0.82
7	90, 90½	13.24	84.00	2.11	0.65
9	89½, 89	12.16	84.92	1.97	0.95
6	88, 88½	12.98	84.00	1.96	1.06
3	87	12.71	83.96	2.26	1.07

It is of interest to note that the buttermakers who made the sixty tubs of butter from which samples were obtained, varied the method of making as follows.

The temperature at which the cream was ripened, 48 to 75 degrees F. Length of time the cream was held after it was received before it was churned, 2 to 24 hours. Number of hours the cream was held at churning temperature, one-half to 16 hours. Churning temperature 47 to 62° F. Temperature of wash water, 52 to 70° F.

The tub of butter which contained 4.9 percent of salt was cut two points in score on this account. The only other tub in this lot, cut for the same reason, contained 3.39 percent of salt.

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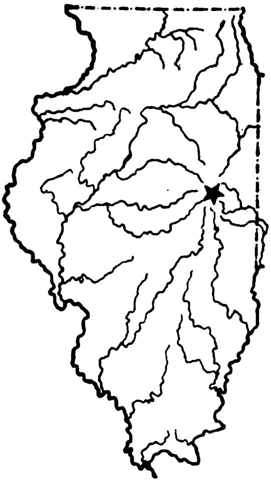
BULLETIN No. 140

DAIRY SUGGESTIONS FROM EUROPEAN CONDITIONS AS SEEN IN THE BRITISH ISLES, HOLLAND AND DENMARK

By WILBER J. FRASER and ROYDEN E. BRAND



URBANA, ILLINOIS, OCTOBER, 1909

SUMMARY OF BULLETIN No. 140

1. Dairying in England is confined largely to the production of milk by milking Short-Horns. The greater portion of the milk is used for direct consumption,—most of the remainder being converted into sweet cream butter in farm dairies. Page 462

2. Dairying in Ireland is limited almost exclusively to milking dual purpose cows thru the summer. Page 469

3. Dairying in Scotland is primarily confined to the making of cheese in the farm dairy. The excellence of the producing Ayrshire and the high quality of the cheese are the points of interest to American dairymen. Page 472

4. British Agricultural Shows are conducted for the sole purpose of stimulating interest in agriculture. Page 481

5. Dairying in Holland is a grass and hay proposition. Their dairy cattle have a great capacity for roughage, which, with but a small amount of oil cake, enables them to produce, economically, a large amount of milk. Cheese is the main dairy product, and is made both on the farm and in coöperative factories. Some butter is also made in these factories. Page 485

6. Dairying in Denmark is the chief occupation of the people. It is conducted in a more intensive manner than in any other country in the world. Dairy cows of high efficiency produce milk which is made into butter of excellent quality in coöperative creameries. Page 503

7. Final conclusions. The uniformly high quality of the dairy cattle, their economical feeding, and the care taken of them and their products were the conspicuous things, and as these four points are the essentials of dairying, the American dairymen can and should learn lessons from the dairymen of Ayrshire, Holland and Denmark. In all the dairy districts visited these points stood out prominently, and need to be emphasized in American dairying. Page 521

DAIRY SUGGESTIONS FROM EUROPEAN CONDITIONS AS SEEN IN THE BRITISH ISLES, HOLLAND AND DENMARK*

By WILBER J, FRASER, Chief in Dairy Husbandry
and ROYDEN E. BRAND, Assistant in Dairy Husbandry

A study of the dairy conditions of Illinois shows conclusively that the dairymen are not getting the profits they should from the money and labor invested in the business of producing milk. Since there are dairy sections in Europe where they are feeding American grown grain to their cows and producing dairy products which are sold on European markets in competition with ours, it is important for the American dairymen to know what is wrong with our methods, and the details of the system that permits profitable dairying on land worth from five to ten times as much as that in the Central West.

This bulletin is the result of a summer spent in making a detailed study of the methods employed in the production of milk on the farms of the intensive dairy countries of Great Britain, Holland, and Denmark. The main purpose in the study was to look for points in which European dairymen excel. This was a second visit for the Chief in Dairy Husbandry, who eight years before noted the important features at that time, and the observations of the first visit, coupled with the more mature and deliberate opinions of the second, are herewith compiled. While many of the foreign conditions are, of course, vastly different from ours, and we cannot copy all of their methods directly, the underlying principles of dairying are the same the world over, and the high points of their success are uniformly good cows, economical feeding and care, and sanitary methods, resulting in dairy products of high quality. The observance or non-observance of these points make the difference between success and failure, and are of vital importance to all American dairymen.

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*The cuts for this bulletin were made from photos taken by the authors.

DAIRYING IN THE BRITISH ISLES

ENGLAND

RURAL ENGLAND.

In England the greater part of the land is owned by noblemen, who care quite as much for beauty as for profit, in consequence of which great attention is paid to the artistic appearance of the farms, and much pride is taken in keeping everything neat and orderly. No fence corners or hedge rows are left to grow up with weeds, nor machinery allowed to stand in the fields. England certainly possesses a charm that is all her own. The larger portion of the country is in grass, and neatly trimmed hedges divide the beautiful, undulating pastures and meadows into small fields, where numerous clumps of trees are allowed to grow. Covering the whole country is a network of winding macadamized roads lined on both sides with hedge rows and trees, and leading thru the fields in every direction are foot paths. The heather-covered hills, vine-clad cottages, and cattle dotting the pastures, make a beautiful picture, not soon forgotten.

A TYPICAL ENGLISH LANDSCAPE. MILKING SHORT-HORNS AT PASTURE.

FARM MANAGEMENT

The farms vary in size from fifty to three hundred and fifty acres, averaging about one hundred and twenty acres, and rent for from $2.50 to $10 per acre, depending upon the soil. Their valuation is considered to be thirty times the rental. These farms are often rented by the same family from generation to generation, and it is this stability which makes the English farmer such a successful breeder of live stock. The English renter must not be confused with the European peasant; he is usually a well-to-do and well-educated man, comfortably situated, contented with his lot, and his heart is in his work.

Climatic conditions affect the crops grown, and while there is more uniformity of temperature, there being neither intense heat nor cold, yet very little corn can be raised. On the other hand, grass grows abundantly, as the rainfall is plentiful and well distributed, and for this reason the greater part of the country is in pasture or meadow, only a comparatively small portion being under cultivation. There is also a growing tendency to have more pasture and less tillable land, owing to the difficulty with which labor is obtained. Good permanent grass land is higher priced than arable land. Agricultural conditions vary in England, as in other countries, and it naturally follows that one section differs from another.

HEAVY ENGLISH CART COMMONLY USED ON THE DAIRY FARMS AND FOR DELIVERING MILK.

Usually, grass seed is put in with oats or wheat and always pastured after the grain is cut. A large number of grasses are sown together, as the grasses adapted to the soil will thrive best. A favorite mixture consists of meadow and tall fescue, perennial rye grass, timothy, cock's foot, sweet vernal, and red, white, and alsike clover. Pastures that have been down some time either run to weeds or establish themselves. The chief difficulty is to have the ground firm, and the tramping of stock does much good if the ground is not too wet. The pastures should be cared for by careful stocking, to prevent coarse grasses from seeding and running out the smaller grasses. If the coarse grasses predominate, the pasture then becomes open in the bottom. Pasturing a mixture of stock is best, as they prefer different grasses. Favorite English sayings are: "Never interfere with a good pasture when once it is established," and "Any laborer can look after arable land, but it requires a master to look after grass land."

ENGLISH FARM AT HAY BARRACKS.

Oats, wheat, barley and rye are the grains commonly raised. These are harvested by cutting a swath around the field with a cradle and then using a self-binder as in this country. The crops which are cultivated while growing are mostly roots. Mangels are grown extensively for stock feeding and these commonly yield from twenty-five to thirty tons per acre.

The carts, wagons, tools and implements used by the English farmers seem very crude and clumsy compared with those in the United States, but on the other hand, they are more substantial and much better made. The English farmers are fast seeing the convenience and advantage of our machinery, and are not only using much that is made in the United States and Canada, but are designing and manufacturing implements quite like our own. English Agriculturalists freely admit that they have learned much from Americans about improving and developing farm machinery.

SHIRE MARES GENERALLY USED ON THE FARMS OF ENGLAND.

LIVE STOCK

The Englishman is a lover of fine stock, and as a rule has a much better quality than is seen in this country. The horses used on the farms are largely Shires. Being of the heavy draft type, they are frequently used singly, and very seldom does one man drive more than two horses at a time on the farms.

HERD OF DAIRY SHORT-HORNS WHICH HAS BEEN BRED ALMOST ENTIRELY FOR MILK PRODUCTION FOR TWELVE YEARS. AVERAGE PRODUCTION 6000 POUNDS MILK PER COW PER YEAR. WHITE COW STANDING PRODUCED 7000 POUNDS MILK WITH FIRST CALF, AND OVER 11,000 POUNDS LAST YEAR. AVERAGE TEST 3.8 PERCENT FAT.

Nearly all the cattle seen in England are Short-Horns, with now and then a few Herefords, Devons and Jerseys. Most of the milk of England is produced by milking Short-Horns. Several excellent breeders of Dairy Short-Horns are breeding for milk alone, paying no attention to beef. In this way two classes of Short-Horns are being developed that are almost as different as Holstein-Friesians and Aberdeen Angus.

FEED AND CARE

It is estimated that on good land it requires from 2½ to 3 acres to keep a cow a year. The cows are turned to pasture about the middle of May, and the time at which they are taken off in the fall varies from October 1 to November 1, depending upon the season. Cows are not soiled, and pasture grass is generally depended upon to furnish the entire feed for the summer. When this is done, it requires about two acres of pasture per cow. This will support the cows until the first of August, when they are then turned on the aftermath in the meadow, and from this time on changed back and forth from the pasture to the meadow. Grain is seldom fed to cows on pasture, until after the first of August, when a small amount of cotton seed cake is fed to many of the best milkers. Ordinarily, the winter ration for dairy cows consists of 40 to 70 pounds of roots; 15 pounds of straw; 7 pounds of hay; and 8 pounds mixed meal and cake. The roughage is fed three times a day and the grain twice,—the grain being fed according to the milk flow, and is cut off entirely when the cow is dry.

RED POLLED COWS COMMON IN EASTERN ENGLAND.

JERSEYS AT PASTURE. SEEN ONLY OCCASIONALLY IN ENGLAND.

At the Agricultural Shows there were numerous and extensive exhibits of condiments and condition powders for stock. Talking with stockmen on the farms, it was learned that there is an enormous amount of these materials fed in England. It would seem from this that English stockmen, like many Americans, over-estimate the value of these preparations.

As straw is valuable for fodder, only a sufficient amount is used for bedding

DAIRY SHORT-HORN THAT TRACES TO VOLUME I. OF HERD BOOK.

to take the rough edges off the cobble stones or brick with which the stable floor is paved. A noticeable feature is the care taken of manure. The best farmers have sheds under which it is kept to avoid waste. The barn yards are paved with cobble stones to keep the cows out of the mud.

ENGLISH LABORER'S COTTAGE.

During the summer, cows obtain their water from water holes, brooks, and tile drains. In winter they are watered from a trough in the yard, the water never being warmed, as the winters are not severe.

FARM BUILDINGS

The buildings on the farms are substantial, usually being constructed of stone or brick, and having slate or tile roofs. The houses are comfortable, and much attention is given to neat and artistic plantings around the homes. Our farmers have much to learn from their English cousins in this respect.

CITY MILK SUPPLY

England, with no greater area than Illinois, has a population nearly half as great as that of the United States, and the question of supplying this enormous number of people with fresh milk is a problem of magnitude.

In small towns, milk is delivered warm from the cow, twice a day. In the large cities it must be cooled to stand shipping and the unavoidable delay in delivery. As the climate is cool, it is not as necessary to have the milk chilled to a low temperature during the summer as it is in the States. The customary price to the farmer is $1.40 per 100 pounds for the summer six months, and $1.60 for the winter six months, making an average of $1.50 per 100 pounds, after the freight is paid.

DAIRY SHORT-HORN PRIZE WINNERS AT THE ROYAL SHOW.

An example is cited of a dairy company distributing milk, one of the most extensive in Manchester, owned and operated by Mr. Hailwood. He started in the business while young, and has developed a retail trade until at the present time he owns two farms, and runs twenty one-horse delivery carts and eight distributing shops in the city of Manchester where milk is sold by the glass or quart. He rents a double shop in the main part of the city for $4,000 a year, where he serves refreshments, and employs twenty people. He pays the laborers that work inside his dairies, and also those who deliver milk, six dollars a week.

CITY MILK SUPPLY DEPOT, SHOWING MILK CHURNS AND DELIVERY CARTS.

He buys from 20,000 to 30,000 pounds of milk a day, selling it at 6 cents a quart in summer and 7 cents in winter. Most of the milk is delivered in bulk and in pint and quart buckets, none of the milk being bottled, with the exception of a small amount which is pasteurized and sold in small-necked glass bottles. He sells 50 percent cream in ten-ounce jars, at 12 cents. If the jar is returned, 1 cent is refunded.

DAIRY SHORT-HORNS. A SOURCE OF LONDON'S MILK SUPPLY.

Another example of a dairy company supplying a city with milk is a concern doing a high class business in one of the smaller cities. It has as a depot an excellent two-story brick building with an attractive shop in front where milk is sold by the glass, or in larger quantities. The floors are of cement and the walls of white glazed brick. One entire side of the building and a portion of the roof are of glass, giving ample light in the second story, where most of the milk is handled. A wash room for cleaning cans and dairy utensils is fitted up with every needed appliance and a large boiler furnishes steam for power and sterilizing. There is also a churn room where any milk or cream that is left unsold is converted into butter. About 7,000 pounds of milk are brought daily to this depot by the farmers in the vicinity. The milk is filtered, pasteurized, and thoroly cooled, and is then ready for the consumer. The twenty men employed in preparing and delivering the milk are required to wear white suits. The milk is delivered with twenty push carts, each having a large can called a milk churn swung between the wheels, and attached to the cart are also several pails, some containing cream and others to be used in carrying milk up the hills where it is too steep to push the cart. As the advantages of thoroly cooling the milk are not appreciated, they incur the extra labor and expense of having the milk delivered twice a day at the depot and also to the customers.

MANUFACTURED PRODUCTS

England has practically no creameries or cheese factories. Nearly all of the milk not used for direct consumption is made into butter or cheese on the farm, by far the greater part being converted into sweet cream butter. The excellent and uniform quality of the butter and cheese used on the tables at hotels and in the homes of England is everywhere noticeable. An Englishman would not think of serving butter of as poor a quality as much of that found on the American markets.

As the population of England is over seven times as dense as that of Illinois, a large percentage of the milk produced is used for direct consumption and most of the butter and cheese consumed has to be imported from other countries. The United States is enjoying practically none of this trade. Denmark and Holland, by studying English tastes and demands, have captured the greater part of the dairy imports and are producing them on land worth from $500 to $1,000 an acre.

DAIRY BUILDING ON LORD ROTHSCHILD'S ESTATE.

IRELAND

Altho having the advantage of favorable natural conditions, the Emerald Isle falls behind in agricultural progress, both as regards the peasantry and the capability of the soil, and it naturally follows that the dairy industry is on a par with the other agricultural operations.

Being directly influenced by the Gulf Stream, Ireland has a climate which,—moist in summer, moderate in winter,—exposes almost 20,000,000 acres of land to a long growing season. The climate and soil are especially adapted to the growing of pasture, hay and green crops, and the unique natural advantages particularly adapt the country to dairying rather than grain growing. The general size of the farms also lends itself to the intensive methods, which are practiced where dairying is rightly conducted. Yet, as was mentioned, the agricultural conditions are in some respects deplorable. This is especially true of the more densely populated region of the South-west, where the land is poor.

IRISH FARMER'S COTTAGE.

In the North of Ireland there is much mixed farming, while in the South nearly all of the land is in grass. In the North and Central Eastern parts of Ireland the farms are small. The owners of large estates divide up the land and rent it out in small amounts to numerous tenants, many of these having not over twenty acres.

In striking contrast to the careful housing and care of the dairy cattle in England and Scotland, Ireland practices, in many respects, the loosest kind of dairy methods. Excepting near the larger cities, where a constant supply of milk is required, the cows are generally allowed to go dry in the fall when the pastures fail. During the winter their only shelter may be an open shed. Many of the barns are small and have no loft or hay room, thus necessitating stacking in a moist climate where the hay rapidly deteriorates. In the southern part, many of the cows are fed nothing but hay or straw thru the winter. As the supply of these is often limited, Spring finds many of the cows so badly emaciated and in so weak a condition that they can scarcely get up alone, and it takes a month of fine pasture in the Spring to put them in good condition to produce milk. This reduces the portion of the year when the cows are producing anything like their maximum yield to about three or four months, which means that the earning power of the farm is run at full capacity for only one-third of the time, and for the remaining portion of the year not only the stock, but the labor, as well, is partially or wholly idle. There is certainly little profit in this sort of dairying, and its effects are detrimental to both man and beast. To add to their folly, they attempt to make both milk and beef from the same cattle, which are frequently scrubs and good for neither purpose. Still, these are the conditions existing in a large and exclusively milk producing district of Ireland, where the cattle are descendants from the native stock which have been crossed with the Short-Horns for many years, and bred for beef and milk, until now they are almost a distinct breed.

IRISH LABORER'S COTTAGE.

The great problem is how to supply winter butter and keep the English trade the year round. Coöperative creameries are doing much to aid in this respect. Still the majority of farmers persist in the "one-third year dairying" method. There are some good dairymen, yet the poor ones do not learn to profit by these examples and each year the pastures are consumed with but comparatively small profit. Many Irish dairymen, like so many American dairymen, do things the easiest way, and in consequence reap the small end of the profit.

Notwithstanding the bad practices followed, Ireland has 800 creameries and exports about 140,000,000 pounds of butter a year, which is valued at over $30,000,000. If Ireland could be awakened to her natural advantages, breed efficient dairy cows and feed and care for them properly, she could easily be a great dairy country. Denmark,—only one-third the size, and lacking the natural advantages of soil and climate,—exports over twice as much butter.

Like many Americans, the Irish dairyman is so exceedingly short sighted that he cannot see that an extra yield of 2,000 pounds of milk, worth $25 a year, in a single year will alone more than make up the difference in the butcher's price between a special dairy cow and a dual purpose cow at the end of her lifetime.

The slack methods followed by many dairymen in some parts of Illinois are but little better than those in Ireland, and without improvement it must follow that we have a class of dairymen who are merely existing in a country where the land is fertile and the market for high grade dairy products good.

IRISH COW MARKET, DUBLIN.

SCOTLAND

The dairy region of Scotland is confined almost exclusively to the southern part of the country, and this is the only section that will be discussed. The general appearance of the country is much the same as that of England, the larger portion being in grass, either pasture or meadow, and the crops grown are also similar. It seems like a mistake to till so little of the land, when compared with the more intensive methods of Denmark, where nearly all of the land is under cultivation. Yet grass grows so luxuriantly that it gives a fair return per acre.

AT THE EDGE OF THE VILLAGE OF FENWICK, SCOTLAND.

FARM MANAGEMENT

The usual rotation is oats, oats, hay, hay, pasture for from five to nine years. The methods of seeding, caring for the pastures, and harvesting are much the same as have been described under England. The farms vary in size from 60 to 300 acres, and some are as large as 1,000 acres, but the average is about 100 acres. On a good farm of this size are usually kept 24 cows, 7 or 8 two-year-old heifers, 7 or 8 yearling heifers and the same number of calves. Most of the farms are rented. The rent varies according to the productiveness of the land, and averages $7.50 an acre. As a rule, land valuation is not increasing. In some sections land is decreasing in productiveness because less money is spent in keeping up tile drains, and on account of lax methods of farming, one of the reasons for the latter being the lack of laws protecting the tenant farmer from the unscrupulous methods of the landlord. The present laws seem to put a premium on poor farming, for if a tenant improves his farm, making it more productive, he is almost sure to have his rent raised at the expiration of the lease, and this all tenants very much dread. As a rule, a tenant stays on the same farm for a long number of years, and occasionally a line of tenants remain on the same place for one or two centuries. Land has been known to change hands three times, yet the same line of tenants remain on the farm.

CURING HAY. WHEN DRY THE COCKS ARE PITCHED INTO THE SMALL STACKS AND AFTER ABOUT THREE WEEKS THESE ARE TAKEN TO THE BARN.

BROAD, ROLLING PASTURES OF SCOTLAND. AYRSHIRE HEIFERS IN FOREGROUND.

Scotch dairymen say that the size of farm most profitable is one which can be run by the family, without hired help, which is often expensive and inefficient. Married men get $225 a year, with house and potatoes furnished. Single men receive from $175 to $190 and board.

DAIRY CATTLE

In this section of Scotland dairying is almost the sole occupation of the farmers. The cows kept are practically all high grade or purebred Ayrshires, and as a class are efficient and economic producers. Heifer calves from the best cows are raised on all the farms. A good registered Ayrshire cow brings from $125 to $200 and a good grade cow $80 to $100. Heifers drop their first calf at from 2½ to 3 years of age. The cows that are good producers are kept as long as they are healthy. The poor milkers are disposed of while young, on the dairy market, to other dairymen, or fed for beef. In many herds in Scotland are cows twenty years old, and still good producers, but in herds which are fed heavily on grain they do not last as long, and the oldest cow is not more than twelve years old. As a rule, the sires used are from high producing dams, rather than show stock. On farms where milk is sold for direct consumption the cows are usually dry for six weeks, and on farms where cheese is made, the cows are frequently dry for three months during the winter. The best dairymen expect to receive $100 per cow per year, when the milk is sold at an average price of $1.40 per 100 pounds. To show the efficiency of the Ayrshire cows it is only necessary to state that the production on 18 farms near Kilmarnock in 1907 reached the high average of 6,920 pounds of 3.9 percent milk per cow, including heifers with their first calf. In comparing the yield of the Ayrshire cows in Scotland with the cows in the United States, consideration must be given to the fact that the cows in Scotland are fed very little grain.

A TYPICAL SCENE IN AYRSHIRE.

About one-half of the cows in Scotland are milked by women and girls, and the average is eight cows to the milker. Cows are milked regularly twice a day, and in most herds the milkers are rotated around the herd in a regular order, so that a cow is not milked twice in succession by the same person. This is the universal practice followed in Scotland, the explanation of it being that if there are any poor milkers, they will not spoil a given number of individual cows. In this particular, Scotland is unique, as in all other dairy countries visited, each milker milks the same cows regularly. Scotch dairymen admit that if all the milkers are good, it is best to have them milk the same cows regularly, but if some of the milkers are poor, it is best to rotate them in this manner.

AYRSHIRES, THE DAIRY COW OF SCOTLAND.

There are two types of Ayrshires in Scotland; the show type and the producing type. The show type has been developed for the show ring, and bred for beauty alone. The genuine show udder must be compact and closely attached, both before and behind. The sole must be flat, with no indentations between the teats, and the udder must not protrude behind, but be carried up even with the thighs, and have small cylindrical teats, evenly placed on the flat bottom. This is the only kind of udder that can be shown many years in succession and not become too pendant for the show ring. Any intelligent dairyman knows that this type of udder is fleshy and does not belong to the best producers. This craze for tight, close, shallow udders started in the show ring about twenty-five years ago. It has been of untold damage to the Ayrshire breed, and has split the breeders into two factions,—one of which is breeding for show, and the other for production. The breeders who are breeding for production belong to test associations and keep accurate records of their cows. The latter cows have good udders that milk well away, and large, soft teats that are easily milked. One of the best authorities in Scotland upon this subject says: "The show ring has been a curse to the Ayrshire breed. Ayrshires would be a different breed today had there never been a show. The leading exhibitors of show Ayrshires of the flat, fleshy udder type have not made money, even if they have sold their stock at large prices, because they did not get enough milk to bring up the profits. One of the leading exhibition herds produced only half as

AYRSHIRES WAITING FOR THE MILKING HOUR.

much per cow as did another herd bred for production alone. This shows the folly of running to fads. You American dairymen are making a great mistake in allowing showmen to be your importers, as they are taking over only the show type. By this means you are losing, to the American Ayrshire, the advantages of our record Ayrshires in the economy of milk production."

AYRSHIRE CALVES AT FEEDING TIME.

As an illustration that show Ayrshires are not producers, the ring of aged cows at the Royal Agricultural Show last year is a good illustration. The cows placed at the lower end of the show ring were at the head in the production class. They stood as follows:

Inspection class	1, 2, 3, 4, 5.
Production on yield of milk	5, 4, 1.

The cows receiving 2 and 3 in the inspection class were not shown in the production class.

Record Ayrshires are gaining rapidly in popularity. At the Highland Show Ayrshire cows must produce, the night and morning before the exhibition, 36 pounds of milk, or they are not eligible to enter the show ring. This has the advantage of preventing the cows being bagged before showing. To prevent fraud in all competitions, cows are milked out in the open. Foolish fads are gradually passing away, and at the present time color does not count for much, in the Ayrshire show ring in Great Britain.

PROMISING YOUNG AYRSHIRES.

FEED AND CARE

The cows are usually given nothing but pasture during the summer from May 10 until September. After this they get the aftermath in the meadows, which keeps them until about November 1. Soiling crops are not fed, excepting some cabbage in the fall. The amount of pasture required per cow for the summer will vary from one and one-half to three acres, depending upon the land. During the winter, dry cows are fed some roots, and all the straw they will eat, but no hay or grain. Cows giving milk usually receive about 12 pounds of straw, 6 pounds of hay, and some grain,—the amount varying greatly, depending upon the production of the cow. The Scotchman feeds his good producers well, but does not waste grain on dry cows or those giving a small amount of milk. As a rule, the grain consists of bean meal, Indian corn meal, oil cake, bran and dried brewers' grains. The cows are turned out each day for a half hour during the winter to drink from a pond, stream or trough. They are given warm slop in the stable at mid-day.

MILKING TIME IN A SCOTCH STABLE. RECEIVING PAILS IN FOREGROUND.

Calves are never allowed to suckle their dams, but are fed whole milk for six weeks, then skim milk or whey with an addition of oil cake until they are five months old. After this they are given nothing but good pasture, when it is available. Yearling heifers are maintained exclusively on pasture during the summer, and in the winter they are given oat straw with 2 pounds of cake per day, or hay and no cake.

FARM BUILDINGS

The buildings on the farms are usually made of stone, with slate roofs. These are naturally substantially built, and many of them last for more than a century. The buildings are usually placed around an open court,—the house on one side, with the cheese room and cow stable forming the side adjacent to the house, and connected with it. The hay barn forms another side, usually connected with the cow stable, and the horse barn and tool shed are on the fourth side.

BUILDINGS OF A SCOTCH FARMER. HOUSE IN CENTER, COW BARN ON RIGHT, AND TOOL SHED ON LEFT, FORMING A COURT IN CENTER.

The cow stable is always one story, with both windows and ventilators in the roof. The stalls are double and the cows head directly against the wall, with no feed alley in front. The floor is of cement or brick, and the whole stable is exceptionally clean and sanitary. The sides and stalls are kept neatly whitewashed and the floor is scrubbed every day. These are the conditions on the average cheese farm in Scotland.

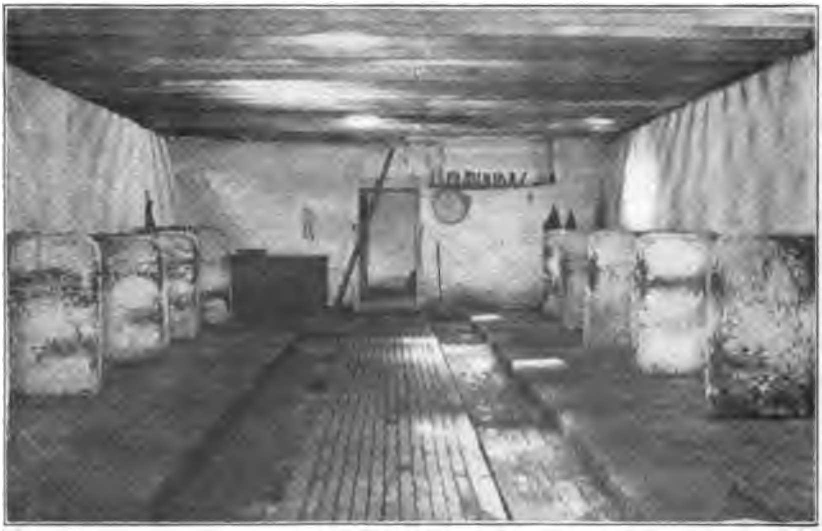
DAIRY BARN AND HAY BARRACKS ON A FARM IN SCOTLAND.

CITY MILK SUPPLY

The method of supplying milk to the cities and towns in Scotland is much the same as that of England, which has already been described.

MANUFACTURED PRODUCTS

Most of the milk not used for direct consumption is manufactured into Cheddar or Cheshire cheese, and this is almost universally done on the farm. While this necessarily involves more labor than when made in factories, on the whole a better quality of cheese is se-


INTERIOR OF COW STABLE. DOUBLE STALLS DIVIDED BY GLAZED TILE PARTITION. THE FLOOR IS PAVED WITH BRICK, AND IS SCRUBBED DAILY.

cured, and the extra price received more than pays for the increased labor involved.

A cheese making room, always having a cement floor, an abundance of light, and kept in a clean and sanitary manner, is usually close to the cow stable. In this room are to be found all necessary utensils and equipment for making cheese. The cheese is sold, wholesale, for about sixty shillings per hundred weight, which is $15 per 112 pounds, or 13⅓ cents per pound.

Comparatively little butter is made in Scotland.

FACTORY WHERE THE MILK ON A LARGE FARM IS MADE INTO CHEESE. CURING ROOM ABOVE. NOTE SUBSTANTIAL CONSTRUCTION OF BUILDING, AND VENTILATORS ON ROOF. SCOTLAND.

HIGH POINTS IN SCOTCH DAIRYING

For the American dairyman, the striking features of Scotch dairying are the uniformly good cows kept, the excellent care given them, and the attention paid to feeding them economically on a small amount of grain, never wasting concentrates on cows that are not producing heavily.

To the Ayrshire and dairy interests of America, it is imperative that the Ayrshires imported be not of the show type, but the magnificent producing record Ayrshires so often seen in Scotland. When we consider the low efficiency of the average cows milked in America,

BUILDINGS ON AN AYRSHIRE DAIRY FARM. IN THIS CASE THE STABLING FORMS THE SQUARE COURT AND THE HOUSE IS OUTSIDE, BUT ADJACENT.

compared with the average Ayrshires milked in Scotland, it is easy to see the great possibilities yet unattained by the dairymen in this country.

To the American cheese maker, the excellence of Scotch cheese is well known, yet the secret of the success in making cheese of such a high quality lies not so much in the skill of the cheese maker as it does in the care taken of the cows, stable, cheese room, and utensils. thus keeping the milk clean so that it is delivered to the cheese vat in almost perfect condition.

A LABORER'S COTTAGE, SCOTLAND.

AGRICULTURAL SHOWS

No discussion of dairying in the British Isles is complete without mentioning the influence of the agricultural shows.

The British appreciate an agricultural exhibit as do no other people in the world, and if there is one thing they do know how to do better than another, it is to arrange and conduct such an exhibition in a high class manner. Their shows are quite unlike American, and we can learn many valuable lessons from our British cousins in this particular. No horse races, side attractions or catchpenny schemes of any kind are allowed on the grounds; the people attend to learn instead of to be merely entertained by some fake show, as is too frequently the case in this country. Another most commendable feature is that everything is in readiness the morning of the first day. All exhibits must be up and completed the night before the show opens or leave the grounds at once. Coupled with this fact the judging begins early the first morning and is vigorously pushed, thus making the first day much the best of all, which is a great advantage, as it makes every day interesting and people are not obliged to wait until the last day to see how the ribbons are to be tied.

PARADE OF DAIRY CATTLE, BATH AND WEST AGRICULTURAL SHOW, ENGLAND.

JERSEYS BEING JUDGED. ENDS OF DAIRY SHEDS IN BACKGROUND. ROYAL AGRICULTURAL SHOW, ENGLAND.

There are many smaller agricultural shows held in the different shires, but as they are quite similar, excepting in size, a description of the Royal, the Bath, and West Agricultural Shows of England will suffice.

AYRSHIRES IN SHOW RING. ROYAL AGRICULTURAL SHOW, ENGLAND.

The general scope of the work of the Royal Agricultural Society, under the auspices of which the Royal Show is held each year, is well summed up in the Society's motto: "Practice with Science." In England everyone is interested in agriculture, from the King down to the lowliest laborer, and no man is considered well educated unless he possesses a reasonable knowledge of the subject. The entire royal family hold memberships in the Royal Agricultural Society.

The most prominent farmers and breeders come together at this show to study the best specimens of live stock the country can produce and to exchange ideas as to the best methods of breeding, feeding and handling live stock. They also see the latest inventions and most improved implements and machines for doing all kinds of agricultural work. Some idea of the extent of this exhibition may be gained from the fact that the grounds cover 100 acres and the exhibits are placed close together. This show has not been permanently located, but has been moved each year, thus necessitating temporary buildings, which, however, are very comfortable. Owing to the vast amount of work to be done to get everything in readiness on grounds of this size, the work begins about six months prior to the show, and by the time the opening day arrives everything is completed.

DAIRY SHORT-HORNS IN MILKING CONTEST. ROYAL AGRICULTURAL SHOW, ENGLAND.

The judging began the first morning at nine o'clock and was vigorously pushed, as may be imagined, when we consider that at the Royal there were about 700 entries of cattle, the same number of horses, and nearly as many of sheep and hogs, yet the judging was practically completed by noon the first day.

The dairy breeds were represented by Ayrshires, Jerseys, Guernseys and Kerreys, the Short-Horns being exhibited as a strictly beef breed, the same as in this country. There was, however, an exhibit of unregistered dairy Short-Horns. The cattle were paraded each morning in an immense ring, which was surrounded by a crowd of admiring spectators. In the afternoon the horses were paraded,, and later in the day judging of the harness classes took place. There were at all times large crowds around the show rings, stalls and pens. People came from all parts of the British Isles to attend this show, which lasted six days, and one day 52,000 people were admitted to the grounds. The amount of money offered in premiums was nine thousand, nine hundred and sixty-nine pounds, or about $50,000, exclusive of the champion prizes and many valuable medals offered by the different breed societies.

GUERNSEY STABLE. ROYAL AGRICULTURAL SHOW, ENGLAND.

Besides live stock there was an extensive exhibit, numbering more than four hundred stands, of all kinds of agricultural and dairy implements and machinery, from small hand tools to harvesting and threshing outfits, and a large number of wagons and vehicles of all kinds and descriptions, consisting largely of carts, many of which were heavy and high.

ONE OF THE AVENUES IN THE DAIRY AND FARM MACHINERY EXHIBIT. ROYAL AGRICULTURAL SHOW, ENGLAND.

The most attractive part of the dairy exhibit was the working dairy, which was located in a large building erected for the purpose and which accommodated forty hand churns and butter workers. In this building could be seen some kind of dairy work in progress at all times during the show. Separating, pasteurizing, and cooling milk occupied the morning hours and later each day two butter-making competitions for prizes, by dairymaids, took place. These contests were well filled and revealed many excellent buttermakers. There was a milking contest which was rather a novel feature and created a great deal of interest. Each contestant was required to milk three cows. Dealers in dairy apparatus and machinery had many fine stands. This was a most interesting part of the show, for both the separators and utensils used were quite different from ours.

WORKING DAIRY. BATH AND WEST AGRICULTURAL SHOW, ENGLAND.

It is difficult to describe an English show so that one who has not been in attendance can really appreciate its value, but a week's stay at the Royal Agricultural Show of England is well worth a trip across the Atlantic.

DAIRYING IN HOLLAND

The time spent studying dairying in Holland was devoted to the richest and most intensive dairy regions, viz., the provinces of North Holland and Friesland, which take the lead in both quality and numbers of dairy cattle. It is to this section of the country that the following description is devoted.

On the first visit we entered the country thru the Maas river, and as we steamed slowly up for thirty miles to the city of Rotterdam we received our first impressions of Holland with its numerous canals, level fields, and beautiful herds of dairy cattle. The richest and best agricultural sections of the country lie below the level of the sea and have been rescued from it by means of dikes, canals and windmills.

Road on top of the dyke running around the Zuider Zee. The water in the sea on the right is 12 to 15 feet higher than the land on the left. Notice meadows dotted with cattle.

Sailing up the river we saw cows in the pastures and hay being made in the meadows several feet below the level of the river. Coming into port, after crossing the Zuider Zee, all that could be seen from the deck of the steamer was the roofs of the houses in the village. The whole country is a perfect network of canals and is thickly dotted with large, picturesque Dutch windmills. Near Zaandam sixty-five of these mills could be counted from the train window at one time. In many portions of the country the canals, which are from ten to twenty feet wide, are not more than ten rods apart. The water flows slowly along, being gradually pumped to higher levels by means of engines or large windmills, until, after passing for a long distance thru large canals with immense dikes on either side, it finally reaches the sea.

Something of the energy of the Hollanders can be imagined by considering that all the country roads are either macadamized or paved with brick, and that all of the water has to be pumped out of the country and kept from one to two feet below the surface of the land. The ditches formed by this drainage system are divisions between the fields, making fences unnecessary excepting along railroads or to enclose small paddocks. A passage from one pasture to another is afforded by a bridge over the canal, or sometimes by filling in earth over large tile, so as not to obstruct the flow of water. Posts are set on either side and a gate closes the passage.

WINDMILL AND ENGINE HOUSE USED FOR PUMPING WATER FROM CANALS INTO THE ZUIDER ZEE ON RIGHT. A LARGE STORAGE RESERVOIR EXTENDS FROM THE MILL BEYOND THE ENGINE HOUSE. THIS CONTAINS A RESERVE WATER SUPPLY, AND IN DRY TIMES CAN BE LET BACK INTO THE CANALS IF DESIRED FOR IRRIGATION PURPOSES. SEA WATER CANNOT BE USED ON ACCOUNT OF THE SALT.

Holland contains but 8,000,000 acres, or less than one-fourth the area of Illinois, only one-third of which is really good land, as large tracts in the eastern part are merely peat or barren sand. This comparatively small area of land, equivalent to one-twelfth the area of Illinois, has developed important things, agriculturally. The size seems to be no hindrance to progress, as over five million inhabitants, noted for their thrift and cleanliness, make their living on this small area. Their exports are $14,520,000 worth of butter and $12,480,000 worth of cheese, making a total of $27,000,000 annually. At this rate, Illinois would have to export $108,000,000 of butter and cheese.

REAR VIEW OF FARM BUILDINGS SHOWING MANURE PILE WHICH IS TO BE SPREAD ON THE PASTURE IN AUGUST.

Most of the farms are owned by the men operating them. These energetic farmers keep their places in the best of condition, and drive to town in a substantial, well finished two-wheeled carriage, behind a sleek, chunky, active horse. A poor farmer is seldom found, as the life of the Hollander has been devoted to the one subject—dairying—and his education has been such as to make him appreciate the importance of thoro, careful methods. His children are well educated, and in some cases are sent to another country to complete their study of foreign language.

From an agricultural standpoint, Holland is one of the most interesting dairy countries in the world. Tho frequently ignored by tourists, it is full of interest, instructive sights, and quaint old customs.

Their conditions differ so markedly from ours in many respects that it is impossible for us to learn much from them that we can copy directly, yet there are many underlying principles which are worthy of our most careful study. The foresight shown by these people in providing permanent roads, buildings and equipment for their dairy work, and many of their cleanly methods could well be studied and copied on this side of the Atlantic.

FARM MANAGEMENT

There is little grain farming or mixed husbandry in Holland and almost no stock is to be seen excepting dairy cattle. Dairying is the principal occupation of the Dutch and the greater portion of the land is either in pasture or meadow. Milk production is practically a grass proposition. Plows and grain raising are almost unknown in the intensive dairy sections.

The farms are much smaller than with us. They vary somewhat in size with the locality, but usually contain about twenty-five hectares, or sixty acres. On farms of this size the live stock will usually consist of about twenty-two cows, nine heifers, forty sheep, fifteen pigs and one or two horses. Of this land

A FAMILIAR SCENE DURING SUMMER IN A HOLLAND COW PASTURE.

about ten hectares is devoted to meadow and the rest pastured, as dairying is conducted on a strictly grass basis. There is such an abundance of moisture that the grass grows very luxuriantly and some seasons great difficulty is experienced in curing hay.

Early May sees the cows turned to pasture, and the method of feeding for six months is then very simple, as the cows only crop the grass in the pastures. It is rare to find a field larger than five acres, so the cows are easily restricted to a small area and are frequently changed from one pasture to another, so that the grass may be renewed in growth and freshness. A drought in July or August may cause a shortage of grass, and some oil cake may be fed, but as a rule the cows subsist for six months on grass alone. An exceedingly wet season causes the grass to grow in excess and if it is too wet to be cured as hay it is cut and put in the ground or stacked and covered with mud for use as grass silage.

GATEWAY TO A HOLLAND PASTURE. THE CANALS MAKE FENCES UNNECESSARY. THE BRIDGE OVER THE CANAL IS THE USUAL COMMUNICATION AFFORDED BETWEEN PASTURES.

As the Dutch dairy farmer has nothing but grass, and no land to plow or crops to till, it would seem that he would have an easy time during the summer, but a closer acquaintance with his methods shows that this is not the case.

The pastures and meadows receive special care. Thru the summer the pastures are gone over at frequent intervals and the cow droppings gathered with shovel and wheelbarrow and placed in piles, thus preventing the waste occasioned by fouling the grass, and the tufted appearance so often seen in our pastures. During the winter these droppings, having decomposed, are again spread upon the pasture. The fields are usually pastured one season and in meadow the next. The manure from the winter before has been carefully stacked and rotted, and the liquid confined in a cistern. In August this well rotted manure is hauled onto the pasture by means of a three-wheeled, one-horse wagon. The manure is put in piles of two to three hundred pounds each, 25 feet apart, making an application of from eight to ten tons per acre. These piles are later carefully and evenly spread over the land and after each pile is spread the man goes over the ground, hitting the chunks a glancing blow with the fork so as to pulverize it all very thoroly. Besides this, the cleanings from the canals, the mud and rank growth of soft reeds and water plants that are yearly removed when the sides of the canals are cut down, are placed in piles, and after they are thoroly rotted are applied as fertilizers to the land.

Some meadows are cut twice in a season, and under ideal conditions it is not infrequent for the grass to grow as much as fifteen inches in a single month. Their method of handling hay seems crude, indeed, to an American farmer. The grass is cut with a scythe and raked by hand. The Dutch farmer claims it is cut closer and that less injury is done the soft sod by this method. When once begun, the mowing proceeds uninterruptedly, regardless of the weather. When partially dry the hay is put into small cocks and later, as the curing advances, these are piled into larger ones, and so on until it is sufficiently dry for the mow, when it is hauled to the barn in a one-horse wagon. It often happens that these piles are wet thru by rain and have to be re-spread and dried, so that the hay may lose its greenish color and aroma, but mustiness or decay is never permitted, and the cows relish the hay as their winter ration.

DAIRY CATTLE

One of the first things that attracts the attention of the traveler in Holland is the large number of fine black and white cattle. Thick as are the sheep on the Cheviot Hills of Scotland, even more numerous seem the black and white cattle on the level pastures of Holland. Everywhere, as far as the eye could reach, the landscape was thickly dotted with fine cows. A more beautiful dairy scene could scarcely be imagined. History tells us that for two thousand years the country now known as Holland has been famed for its cattle. For the last two or three centuries these cattle have possessed good dairy qualities, which have been gradually improved until we find today a breed of dairy cattle of a high order of excellence. Altho only a small percent of the cows are registered, practically all look like pure-breds.

Importations of Holstein-Friesians to this country did not become frequent until about forty years ago, but they have spread rapidly, and at the present time are found in every state in the union.

Successful dairying depends largely upon efficient cows, keeping them comfortable at all times by properly supplying their wants, and treating them kindly. In this particular the Dutch cannot be excelled.

In establishing so fine a breed of dairy cattle, they owe their success, in no small degree, to the careful selection of their breeding stock. Only a few of the choicest bulls are kept for sires and the greatest care is also exercised in selecting females. The cows, as a rule, are excellent individuals,—a threefold method of selection being employed: first, in the sire; second, in the young calf, judged largely by the milking qualities of the dam; and lastly, the greatest of all tests is applied,—performance at pail. Not till the cow answers this satisfactorily is she accorded a permanent place in the dairy.

In America nothing but black and white Holsteins are eligible to registry, and red and white are met with only occasionally, while in Holland the red and white are seen in all parts of the country. In the province of Friesland are three men who are breeding nothing but red and white Holstein-Friesians.

MILKING TIME IN HOLLAND.

One of the most interesting features of the trip thru Holland was a visit to the farm of Mr. Kuperus. For many years this gentleman has been one of the largest exporters of Holstein-Friesian cattle to the United States and elsewhere. He has an exceptionally fine herd of dairy cattle and keeps a careful record of each cow in the herd by testing the milk every two weeks. The average yield of thirty of his best cows for one year was 11,275 pounds of milk and 394 pounds of butter fat. The average lactation period was 306 days and no cow was milked more than one year. His best cow gave in 329 days 18,986 pounds of milk and 585 pounds of butter fat. He has one cow with an average test for the year of 3.89 percent butter fat. This shows something of the character of the cattle that Mr. Kuperus is breeding and it is not strange that he has won many prizes at the different agricultural shows where he has exhibited.

At the present time there are over 250,000 cows in Friesland, 15,000 of which are registered. Test associations started in the province of Friesland eight years ago, and today there are over two hundred of these associations, having twelve members each.

Cattle markets are held once a week in many of the towns. One section of the market is devoted to discarded dairy cows which are sold for beef. Another section is devoted to springers and cows in milk which are to be sold to dairymen in South Holland. The cows sold on these markets are usually of an inferior quality. At Leeuwarden there was a large market for heifer calves, which go to South Holland to be raised, and later many are sold from there to Belgium for milk and beef. Registered cows of good quality are worth from $120 to $200.

THE COWS ARE BROUGHT INTO A SMALL PASTURE AT MILKING TIME. AS SOON AS DRAWN, THE MILK IS TRANSPORTED TO THE CHEESE FACTORY IN THE CANS ON THE DOG CART AT THE GATE.

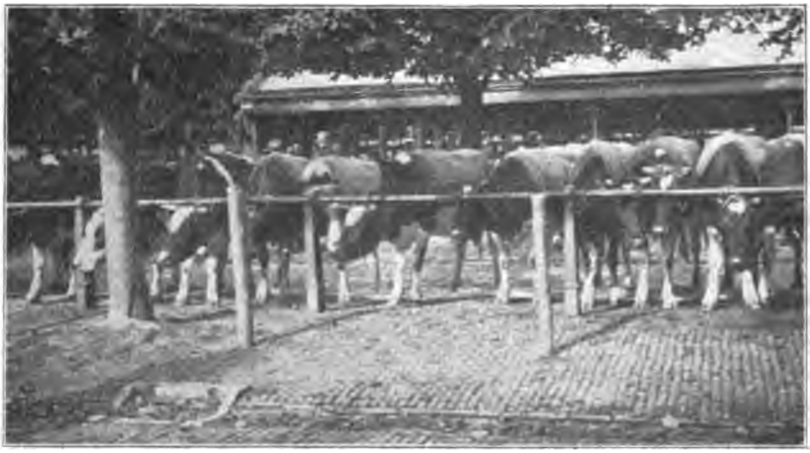
FEED AND CARE

The cows are turned to pasture about May first. During the cold, damp days of early Spring the cows wear blankets in the pasture to protect them from the weather. At milking time they are not driven to the barn, but are milked in the pasture or a paddock, and the milk brought back with a horse or dogs and cart. At the approach of the cold winds of November the cattle are taken from the pastures and put into the stable and not let out again until the following spring.

The feeding is done by the farmer, and all the feed, and many times the water, is carried in between the cows from the rear. The winter grain consists almost entirely of oil cake, fed only to the heavy milkers in quantities of from two to four pounds a day. The principal feed, however, is hay, each cow receiving nearly thirty pounds daily. It takes the great capacity of these cows to handle such a large quantity of roughage, and special care is taken to see that they are always ready for their feed. The cows are given the best of care. They are carefully curried and their tails suspended by a string from the ceiling, so that while the animal has free use of its tail, it can never get into the gutter to be fouled. Scarcely an hour passes, day or night, that the cows are not visited by an attendant. They are watered, fed, and milked with the greatest regularity, and given every comfort possible.

CALF MARKET, LEEUWARDEN, HOLLAND.

Caring for the cows, gathering food for them, and the manufacture and sale of the product occupies the attention of the Hollander to a degree difficult to understand unless one has paid them a visit. Holland is often called the cow's paradise, and it well deserves the name.



"BEAST MARKET," LEEUWARDEN, HOLLAND, WHERE HUNDREDS OF FARMERS, IN THEIR LONG BLUE FROCKS AND WOODEN SHOES, GATHER ONE DAY EACH WEEK.

MARKET DAY IN LEEUWARDEN, HOLLAND. A BOAT BEING LOADED WITH COWS.

HOLLAND COW STABLES

It is not easy for a stranger to gain access to a Holland home, but it was our good fortune on both visits to Holland, in company with interpreters who were acquainted in the vicinity, to get inside of many farm homes in North Holland, where the house and stable are under one roof. These homes are models of neatness, and are interesting in the extreme. The buildings are commodious, the roof steep and the eaves rather low, usually not over ten feet from the ground.

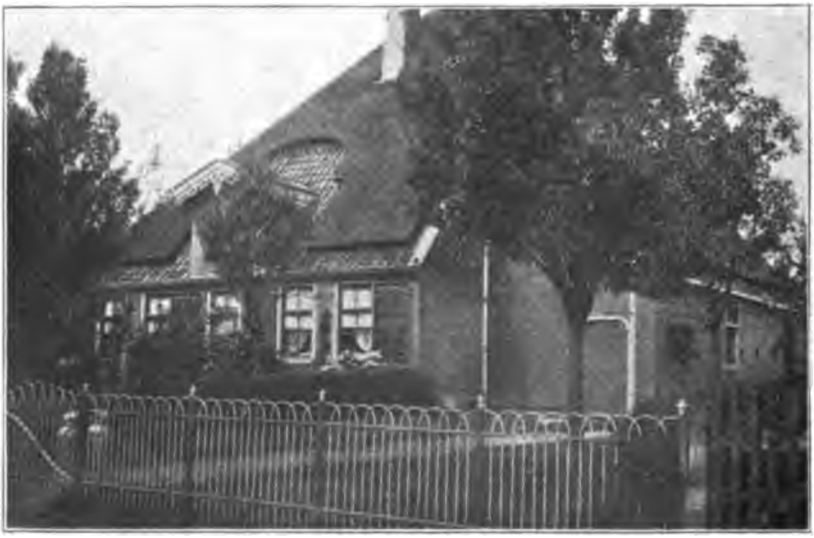
TYPICAL HOLLAND FARM HOME.

The walls are built of stone or brick and the roof covered with an ingenious arrangement of tile and thatch, giving the building a substantial and artistic appearance. The one building contains the cow stalls, wagon shed, hay loft and living apartments.

SHOWING THE USUAL LOCATION OF A HOLLAND HOME. THE BRIDGE, AFFORDING A COMMUNICATION BETWEEN THE ROAD AND HOUSE, IS CLOSED IN THE MIDDLE WITH A GATE.

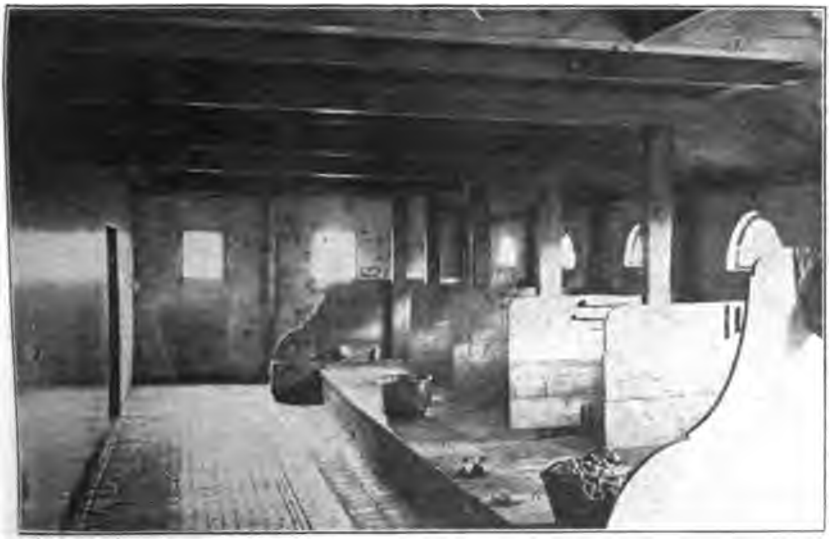
The houses are usually richly and artistically furnished—much better taste being displayed than is often seen in America. The furniture is of good quality and many times some finely carved old pieces are seen. The Dutch love music, and a piano is not infrequently a part of the household equipment.

The stables are as different from what we are accustomed to in America as one can well imagine. A cow stable in America is usually an untidy, uninviting, and in many cases absolutely filthy place where, to the disgrace of civilization human food is produced. In Holland a cow stable is as clean and carefully cared for as any other room in the house. The Holland cow stable usually contains from twelve to



FARM HOME. HOUSE AND COW STABLE UNDER ONE ROOF. DOUBLE DOORS IN BARN. WINDOWS IN PARLOR.

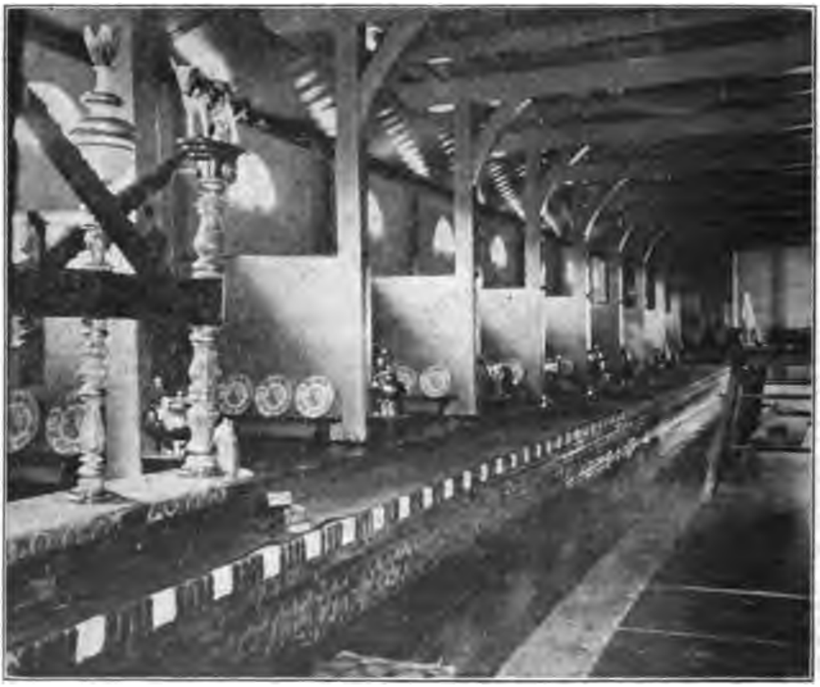
sixteen double stalls, the floor of which is raised about eighteen inches. In one stable this portion of the floor was covered during the summer with small white sea shells; in another it was covered with matting, while the floor behind the stalls was of polished stone. The woodwork in all of the stables was neatly painted a bright blue. Some are elaborately appointed. On the floor of one stable, around each stall was a row of china plates, and at the end of each division between the stalls was a milk stool on which rested a plate. In one stable a polished copper teakettle occupied the stool at each stall and the partitions between the stalls were covered with fine rugs. The small semicircular windows in front were draped with lace curtains. In one end of this room was exhibited a fine specimen of wood carving. The



A TENANT FARMER'S COW STABLE IN HOLLAND. NOTE THE RAISED PLATFORM AND DOUBLE COW STALLS WITH WINDOWS IN FRONT.

family frequently occupies a portion of the stable itself. In several instances the dining room was at one end of the stable and either a sewing room or kitchen at the other end. The parlor and other living rooms are separated from the cow stable by a single partition.

When winter comes the plates, shells and carpets are removed. The cows are arranged in the stalls so that the largest ones are in the center, thus giving the herd a more uniform appearance and causing them to make a more pleasing impression upon a prospective buyer. Since so many of the cows are sold for dairy purposes, this is a rather important item in the dairy management. Long and short cows are lined on the gutter by means of a double tie, the usual rope from the horns being fastened to one side of the stall and a trace chain attached to a wood or iron yoke about the cow's neck is brought back and hooked over a staple in the floor back of the stall partition, thus preventing her moving forward. A backward step would put the cow in the gutter, and as its bottom is about three feet below the stall floor, one step over the edge is usually sufficient to cause the cow to remember the occurrence and recover herself on the slip edge that protrudes some four inches a little way below the platform on which she stands. This ledge is also used to support the portable approach used to span the gutter while placing the cows in the stalls.



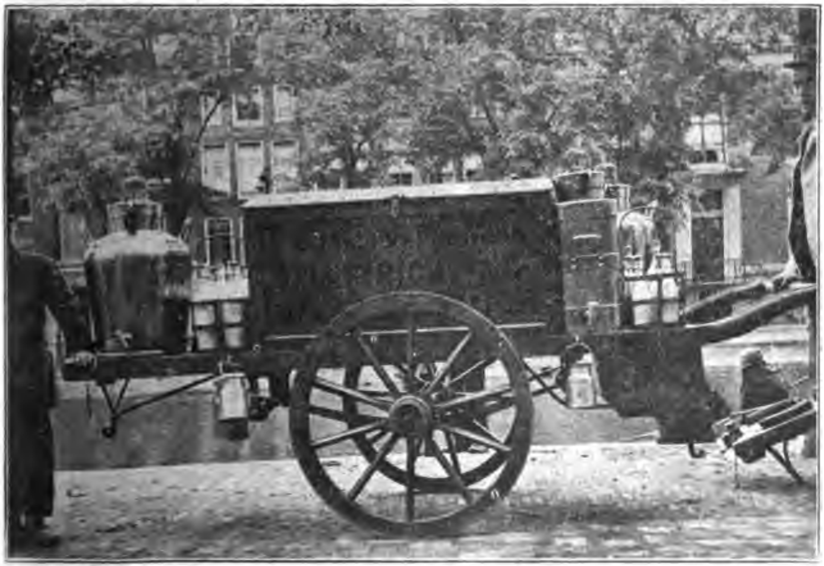
A well-to-do farmer's cow stable in Holland. Stalls for cows decorated with plates, copper tea kettles and wood carving. Lace curtains at windows. Edam cheese curing on table at right. This is the way the stable is furnished during summer months while cows are on pasture.

City Milk Supply

The greater part of the milk consumed in the large cities of Holland is distributed thru central supply houses or milk depots. A visit was paid to one of these depots in Amsterdam where over 16,000 pounds of milk were received and distributed daily. The milk is brought by wagons from farms eight or ten miles out, and by steam canal boat from a greater distance. It is brought in tin cans or wooden casks holding about six gallons.

In Holland, as in all other European countries, they do not appreciate the advantage of thoroly cooling the milk and holding it at a low temperature. In the smaller towns it is frequently delivered warm from the cow and is at best very improperly cooled in the large cities, thus necessitating frequent, delivery, as the milk will remain sweet but a short time after reaching the customer. Nearly half the milk handled by this distributing house is delivered in long-necked, small-mouthed bottles. The greater part of the bottled milk is pasteurized. Milk is sold by measure and not by the amount of butter fat it contains, altho objection is made if the butter fat falls below three percent. The

Farm buildings in Friesland. House and barn not under the same roof, but connected.



Milk delivery cart, Amsterdam. Bottled milk in box and in crates. Bulk milk in copper casks.

Farmer's wagon delivering milk at distributing plant, Amsterdam, Holland.

farmer receives $1.20 per 100 pounds for the milk. The price delivered to the customer is four cents a quart for whole milk, two cents for skim milk, and twenty-five cents for 25 percent cream.

All milk in Amsterdam is delivered by hand, either in a cart pushed by a man, or carried in pails with a yoke. The supply house which we visited runs fifty delivery carts,—a man and a boy going with each cart. The bottled milk is carried in a box in the middle of the cart and usually on each end is a brass cask having copper hoops and handles. As the Hollanders pay much attention to appearance, these are kept highly polished. There are one hundred men and a large number of boys employed,—the men receiving from fifty to ninety cents a day and the boys ten cents. The cheapness of labor accounts for the popularity of hand delivery.

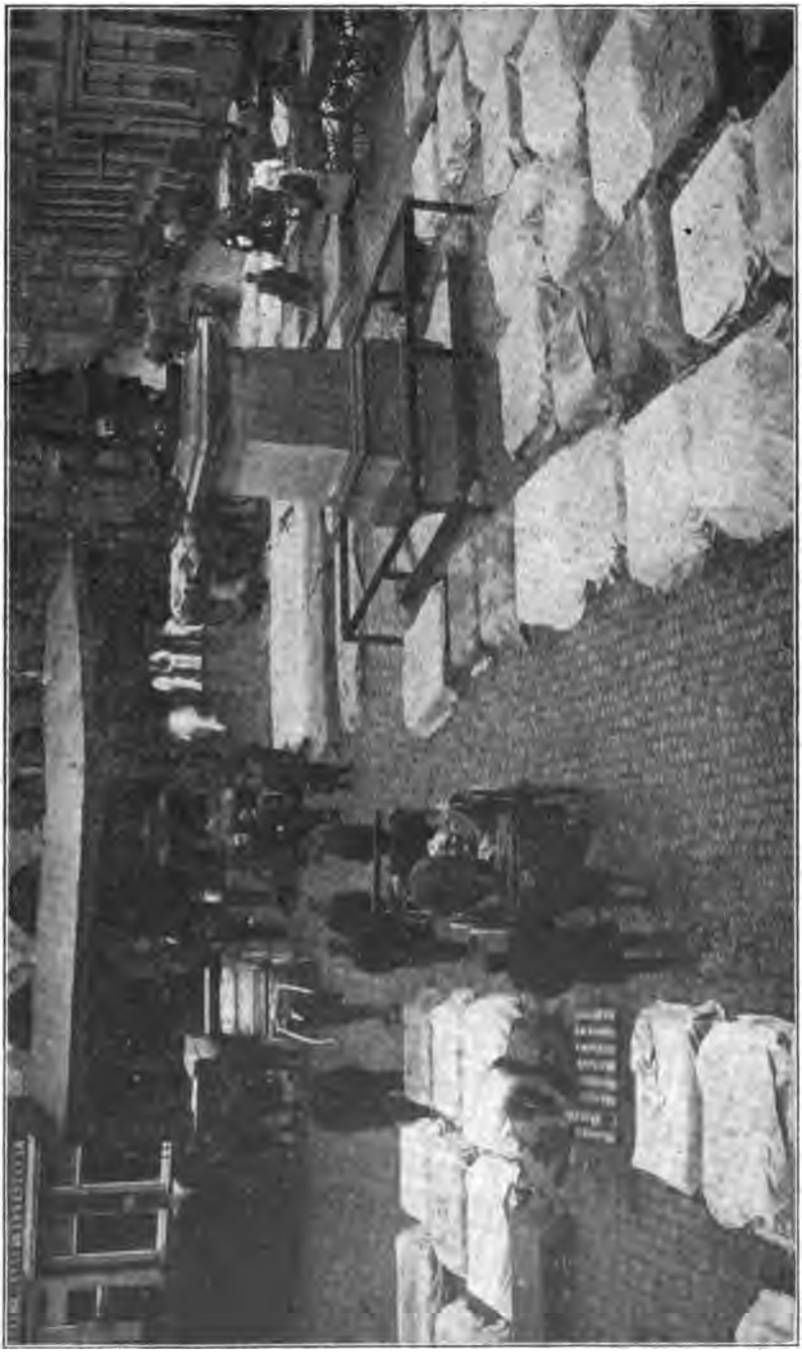
CHEESE MARKET, ALKMAAR, HOLLAND. SHOWING CARRIERS ON WHICH CHEESE IS TRANSPORTED FROM THE MARKET TO THE BOATS.

CHEESE AND BUTTER

At Rotterdam we made a more familiar acquaintance with the chief product for which Holland is noted, namely, cheese. We paid a visit to the commission firm of Leaming & Sons, who are the largest cheese exporters in Holland. They have shelving capacity for 600 tons of Edam and Gouda cheese, these being the two varieties most commonly made in Holland. In the province of North Holland, Edams are made almost exclusively, and until recently were made in the farm dairies. During the last few years factories are coming in quite extensively. The Edam is the spherical variety, and when sold in America is stained red. In Holland they are left their natural color —a deep yellow—being stained only for export. The standard size is four pounds, but some are made as large as eight pounds. We saw one installment of Edams that was to be sent several hundred miles up the Amazon river, and each cheese was encased in a bladder. We were allowed to sample cheese of nearly every description; some were made to the queen's taste, and others so tough that it was difficult to get a trier into them. The price ranged according to the quality, varying from seven to twenty cents a pound.

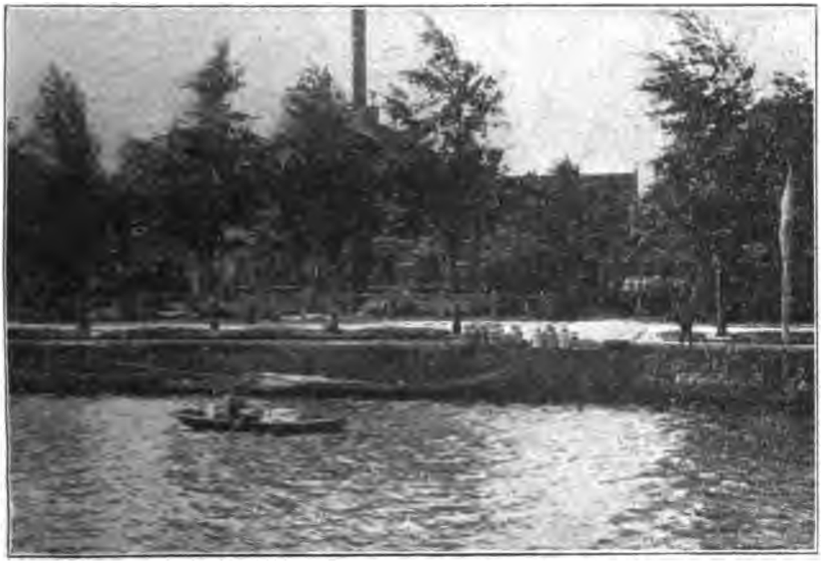
A cheese market is held one day each week in the towns and it was our privilege to visit the towns of Leeuwarden, Pemerand, Hoorn, and Alkmaar on market day. One of the largest markets is in the town of Alkmaar, and as these markets are quite similar a description of this one will suffice. The market consists of a government weigh-house and a square block of pavement. On market day the farmers drive in early with the cheese they have made, pile them in neat piles on straw on the pavement and cover them with a canvas to protect them from the sun or rain. Cheese buyers representing commission firms from the different parts of the country are present. Precisely at ten o'clock the gong sounds, the market opens, and the scene is a busy one. In about two hours we saw 60,000 cheese change hands. After being sold the cheese were removed on carriers, each borne by two men, to the official weigh-house, where they are weighed and then packed into boats on the canal near by and taken to the different cities, or stored in large curing houses close by.

LOADING EXPORT BUTTER AND CHEESE ON BOATS AT THE CLOSE OF MARKET-DAY IN LEEUWARDEN, HOLLAND.



CHEESE MARKET, HOORN, HOLLAND. GOVERNMENT WEIGH HOUSE IN DISTANCE.

In the province of Friesland most of the butter and cheese is made in factories, practically all of which are coöperative. There are 70 coöperative factories that receive on the average 25,000 pounds of milk per day. The average price paid the farmer last year at these factories was 4¾ Dutch cents per lieter, or practically one dollar per 100 pounds of milk. The butter sold on the average at 25 cents per pound and the cheese at 10 to 12 cents.



Delivering milk to coöperative creamery and cheese factory, Leeuwarden, Holland. This factory received milk from 2000 cows. About one-third is delivered by boat on the canal and two-thirds by wagon.

Most of the butter exported from Friesland goes to England. It is put in wooden casks resembling a small barrel. Each cask of butter is numbered so it can be traced back to the creamery and to the churning from which it was made. The butter must contain less than 16 percent of water or the manufacturer is fined.

We visited a combined creamery and cheese factory near Leeuwarden that cost $50,000. This fine brick structure with its slate roof, tile floors, whitewashed walls and ceiling, and everything built in the most sanitary manner possible, is in striking contrast with most of the cheaply constructed creameries and cheese factories in this country, with their soft wood floors, filthy sewers, and general unsanitary conditions. This factory receives 50,000 pounds of milk a day in summer and 16,000 pounds in winter. It comes from 150 farms averaging ten cows each. The milk is delivered twice a day and paid for according to the amount of butter fat which it contains.

FEWER NATURAL ADVANTAGES THAN ILLINOIS

The little country of Holland supports a population nearly twelve times as dense as that of Illinois, and exports an immense amount of butter and cheese, without the natural advantages enjoyed by the Central States. They do, however, have cheaper labor, and the milk flow is not reduced for three months during the summer by the cows being tormented with flies.

MILK HAULER IN HOLLAND. ONE HORSE WILL HAUL TWO TONS ON THE GOOD, LEVEL ROADS.

Here is a country where the land is worth from $500 to $1,000 an acre, and in many cases naturally no better than much of our Illinois land. Yet these people pay their rents or interest on the investment by producing butter and cheese which they place on the European markets in successful competition with that produced in America on land of less than one-fifth the value. They do this in spite of the fact that they cannot produce the amount of digestible nutrients per acre that we can with either corn or alfalfa.

CREAMERY AT LEEUWARDEN, HOLLAND. UNLOADING AT RECEIVING ROOM ON RIGHT. FILLING CANS WITH SKIM MILK ON THE LEFT.

The secret of their success is easily understood, and may be stated in a few words,—efficient cows, excellent care, coöperation, and superior quality of butter and cheese.

DAIRYING IN DENMARK

Denmark is a country of small land holdings. The chief occupation of the Danes is dairying, and in wealth per capita Denmark is next to Great Britain, but has the advantage of having this wealth distributed among the many. One-half of the two and one-half millions of people in Denmark are engaged in agriculture. These self-respecting farmers live in a style of refinement and comfort that is surprising. They are intelligent, industrious, and honest, and their system of coöperation is based on these conditions. Their interests are those of a small nation given up largely to one occupation and one aim so that the difficulties of one are experienced by the many, and that which is beneficial to one is a benefit to the country as a whole.

It is important for the American dairyman to consider briefly the recent history of the agricultural conditions of Denmark and what has brought about the marvelous dairy development. After the Napoleonic wars the country was worn and wasted. When only partly recovered, the Prussian war of 1864 again brought great agricultural and commercial depression. At this time the chief agricultural pursuit was wheat raising, and it did not take the shrewd, far-seeing mind of the Dane long to discover that a continuance of wheat raising on the already worn and impoverished soil was not in accordance with sound. economic principles. Some radical changes in their general methods of farming were imperative if they were to prosper in any marked degree. It is because of these facts, coupled with their present prosperous conditions, that every American farmer should study what has taken place in Denmark, agriculturally, in the last forty years. Some of the factors that led to their success are here noted.

The history of the rise of dairying in Denmark is one of the most interesting and instructive chapters in Agriculture. It is only a generation ago that the Danes changed from wheat raising to livestock. and the cows of the country were very inferior dairy animals, but by a course of careful, persistent and systematic selection and coöperation they have built up two strictly dairy breeds of a high order, and an efficient system of cropping adapted to the largest possible production of milk. To show what Denmark is producing it is only necessary to mention that she exports annually $87,000,000 worth of butter, bacon and eggs, nearly all of which go to Great Britain.

As a part of the general movement for reconstruction, the increase of the high schools and all other agencies of education formed no small part. The number of small holdings was also increased and a general system of coöperation started which was followed later by government assistance. Each community, with the help of its neighbors and the government, has worked out its own plan, based on the principles of economic production and co-operation. It is on these two principles that Danish agriculture is built. While the size of the country lends much to the possibility of a national system of coöperation, the fact that the United States is so large and has such varying aims and conditions does not prevent the application of economic methods, nor does it in any way hinder the development of successfully planned community coöperative interests,—interests, which would greatly aid in the establishment of a uniform product, a dependable basis of supply, and constant markets.

FARM MANAGEMENT

Lying as it does, with the narrow peninsula exposed to the cold north winds, and the islands in a land locked sea, Denmark exposes its area to varying climatic conditions and contains markedly different soils. Compared with the sandy lands of the northern peninsula, the warm, rich soils of the islands are much more productive and enjoy a longer season of growth, calling for different management. It should be kept in mind that the country contains less than 15,000 square miles, or only one-fourth the area of Illinois. On the whole, the land is naturally poor and the climate not congenial. The country lies low and is either flat or undulating. The summers are comfortable, but so short and dry that oats have only time to mature, and of course Indian corn cannot be raised. The cows have to be kept indoors more than half the year.

A TYPICAL DANISH FARMER AND HIS HOME.

The two significant and important factors in Danish agriculture are that ninety percent of the land is owned by the men operating it, and that the greater part of the country is under cultivation. The British farmer has sought economy in putting more land to grass and thus saving labor, while the Danish farmer has found success in the opposite direction. About the only resource of the Danes is their land, and, altho it is in many places poor by nature, they have made the most of it. Improved land laws and systems of land tenure, with education and coöperation, have gradually changed the agricultural conditions of Denmark from distress to prosperity. Large estates have been divided into small farms that are now tilled by their owners. The careless methods of former days have given place to an intensive and skillful dairying. The beef producing cattle have been displaced by dairy cows until they hold full sway on almost every farm and have brought success and prosperity to Denmark.

A LARGE WINDMILL FOR GRINDING GRAIN.

The farms vary in size from ten to three hundred acres, the average being about fifty acres. The whole country is given up to the most intensive methods of agriculture, about seventy percent of the farm land being under cultivation, and the thirty percent, that is in grass, is not pastured. A seven year rotation is in general practice, as follows:

First year	Clover and grass
Second year	Clover and grass
Third year	Rye
Fourth year	Wheat
Fifth year	Roots
Sixth year	Barley
Seventh year	Oats

The land is in grass only two years. The first year it usually grows a strong crop of rye, grass and clover. Part of this is carted to the barn and fed to the cows green, part is eaten off by the cows being tethered on it, and the remainder is made into hay. The second year in grass, the land is treated the last of April or first of May with the liquid manure which every farmer carefully saves in a cistern. In this way they produce heavy crops of grass, for the first crop is generally good as a result of previous manuring.

DANISH FARM COTTAGES.

The rye is cut green for early soiling, and from this time until fall the cows are either soiled with green feed in the barn or tethered on it, or both.

A Danish farm house, with rose garden in front.

The aim of the Danish farmer is to keep the largest number of efficient cows possible on a given area. On the large farms a cow is kept to about two and one-half acres, while on the smaller farms a cow is kept on even less area, as more intensive methods are practiced. In addition to this, enough young stock is raised to keep the herd supplied with cows.

From their feeding of cake and meal and the stall feeding of green crops, an immense amount of manure of fine quality is made, and with their careful methods of husbanding the solids in a covered manure pit and the liquids in a cistern, and applying in small quantities at frequent intervals during the rotation, the producing power of their land is increasing from year to year. This, again, increases the number of cows they are able to keep and thus from year to year the country is becoming more productive and more dairy products are being made. But even the Danes have not yet realized the full possibilities of intensive dairying.

Old Danish farm house.

Farm Buildings

The arrangement of the buildings on the Danish farms is quite uniform. They are usually placed in a square around an open court. On the smaller farms the square is frequently incomplete, having buildings on only three sides, while on the smallest farms there are but two buildings, placed at right angles. When the buildings are in a square the house occupies the side of the court toward the road. Opposite this is the hay and straw barn. On one side of the court are the horse stable and cow stable and on the other side the granary, storage for machinery, and the pig sty. In the central court, which is paved with stone, is frequently found a large Danish pump and a horse power for threshing and cutting hay or straw. Outside of this court, but adjacent to the stable, is usually the manure pit, which is walled up four feet on the sides and has an impervious bottom. Many times this has a roof to protect the manure from waste by rain. A cistern for liquid manure is near, and if the manure in the pit becomes too dry to decompose properly, the liquid is pumped onto it. On some of the large farms where the court has more size the manure pit is inside the court.

Corner of Danish court showing cottage and stable. Stork's nest on ridge of roof.

A large Danish barn.

HOUSE ON LARGE DANISH FARM.

Danish buildings are constructed of stone or brick, and on the older ones the roof is of thatch, held on with cross sticks at the ridge. The buildings are kept whitewashed, and with their thatched roofs present a neat, tidy and artistic appearance. The barns are low at the eaves,—not over eight to ten feet, and the height of the peak depends upon the width of the barn. This determines the size of the mow for storing hay over the cows.

The cow stable is universally built with a feed alley in front of the cows. In some of the stables the cows head toward the center, and in others they head toward the wall, but are never placed against the wall with no feed alley in front, as in Scotland and Holland. The floors of the older barns are of cobble stones, but in the more recently constructed ones they are of cement. The cows are fast-

STABLE CORNER OF COURT. DANISH PUMP IN CENTER. HORSE POWER ON RIGHT.

INTERIOR OF COURT ON LARGE FARM. DAIRY ON RIGHT. COW STABLE ON LEFT.

CORNER OF COURT ON A LARGE DAIRY FARM.

ened with a rope around the neck, rods extending from a swivel on this rope below the neck to a perpendicular rod fifteen inches long fastened to a post at either side, giving the cow a considerable amount of freedom with her head. The platform on which the cows stand slopes gently toward the gutter, the latter being about nine inches deep and eighteen inches wide, and connected with the liquid manure cistern.

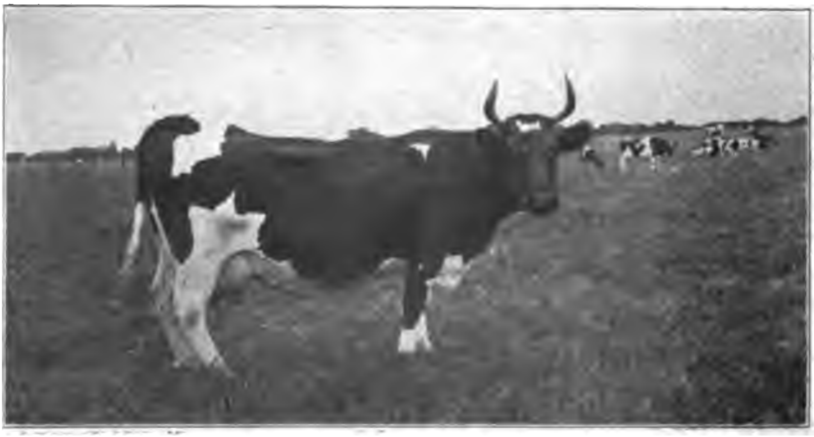
The houses are neat, attractive and homelike, with frequently a fine rose garden in front and large trees to furnish shade.

INTERIOR DANISH COW STABLE.

DAIRY CATTLE

The million dairy cows of Denmark are confined almost exclusively to two breeds,—the Danish Red, of Zealand and the islands, and the Jyske, or Black and White cow of Jutland. Both of these have been developed within the last thirty-five years from the native stock of the country, by careful selection for milk production. The Red cow is a product of a cross of Schleswig blood on the native rather scrubby cattle. The result is a race of fine dairy cattle, weighing from 1000 to 1100 pounds. They are dark red, with black muzzle, medium size, deep body, medium bone, fine skin and well developed udder and veins. The Black and Whites of Jutland have been developed from the beef breed in use in earlier times. They are a larger breed than the Red cows, resembling the Holstein-Friesians in color and size, but are

LARGE HERD OF DANISH RED COWS TETHERED IN SECOND CROP CLOVER, AUGUST 3.



THE BLACK AND WHITE COW COMMON IN JUTLAND. HERD TETHERED IN DISTANCE.

shorter in leg and deeper in body than the Dutch cow. Both of these breeds have a distinctively dairy conformation and are good, economical producers.

The development of the breeds to such a high degree in twenty-five to thirty years has been due to the farmers' skill, intelligence and common sense in selecting and breeding for milk production alone, and the efficiency of these cows is a most striking example of what may be accomplished in a short time if good, systematic work is done and common sense and judgment are exercised. While many of the bulls used are young and untried, they are always individuals of merit and from cows with large records. Only the best heifers are raised, and with the record of the dam and the qualities of the sire known, their selection is comparatively simple, and better cows can be raised than can be bought on the open market. The price of cows is from $80 to $90, some of the best averaging as high as $100, so that it is also profitable from the financial standpoint to raise the young stock to replenish the herd. Heifers drop their first calf at from two to two and one-half years of age, and if they prove to be good producers are usually kept in the dairy until twelve years old, when they are fattened for beef. In fairly good condition, cows bring 5½ cents per pound. Old, thin cows bring less.

COWS AT TETHER. A TYPICAL SCENE ON A DANISH DAIRY FARM.

FEED AND CARE

The cows are treated with kindness and every effort is made to have them comfortable at all times. On many farms the cows are regularly groomed. Tethering the cows on grass is usually commenced the fore part of May, for a portion of the day, at least.

The soiling crops used are rye, oats and peas, oats and vetch, and clover and grass. These are hauled to the barn and fed green, or pastured off by tethering the cows along the edge. In some sections where the farms are small all the land is under cultivation and the cows are kept in the barn until the oats and peas are nearly mature, when the cows are tethered on these during the month of July, after which they are too ripe to be well relished. The cows are then changed to the second crop of clover which by this time is from twelve to eighteen inches high. Some dairymen practice partial soiling all the time, cutting green rye the last of May which was sown the previous September. When this rye becomes ripe in June they feed clover, and when this is mature, about July 1, oats and peas are fed. After these, the second crop of clover is ready. It must be remembered that in the cool European countries it requires much more time for grain to ripen after it is fully headed than in the Central States, thus making the soiling season of the crop much longer. It is the general rule to pasture until short of grass, about July 1, and then soil until the grass is good again. The cows are left on pasture until October, the exact time depending upon the season, thus making the period cows receive green feed extend over nearly six months.

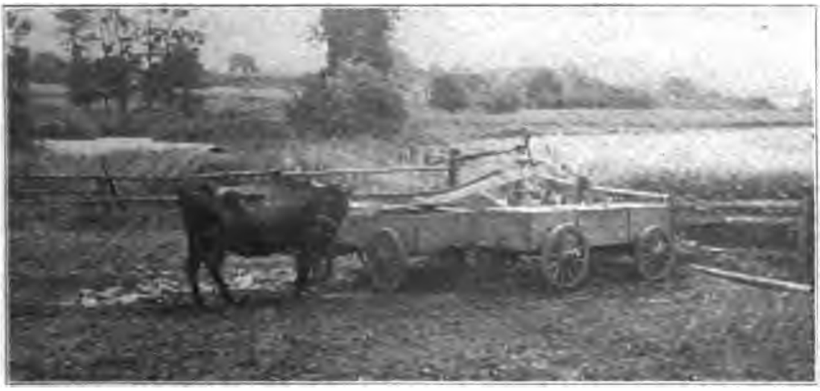
TETHERED IN PLENTY. HARVESTING OATS THREE FEET HIGH, AUG. 7.

BRINGING TETHERED COWS TO STABLE AT MILKING TIME. FIELD OF ROOTS IN FOREGROUND.

The cows are seldom turned to pasture in Denmark, but tethered by means of a halter on the head and a rope or chain twelve to twenty feet long, which is attached to a ten-inch pin driven into the ground. The cows are moved, five times a day, from three to six feet, depending upon the amount of feed. In this manner the crops are grazed off without waste from tramping. The great advantage of this system of tethering is that the crops can be allowed to grow two or three feet high and yet be eaten down without wasting, thus producing much more feed per acre than can be grown on pasture that necessarily must be kept cropped fairly close. This is the Dane's chief point in the economy of feeding during the summer. Practically no grain is fed while cows are on grass. A few dairymen feed a little oil cake to their best milkers.

CALVES TETHERED IN CLOVER.

The usual method of watering is to haul the water in a tank on a low wheeled, one-horse wagon twice a day to the tethered cows. Doors are placed in the top of this tank at either end, and by proceeding directly across the field along the line of tethered cows, stopping the horse midway between the tether stakes, two cows can drink at the same time, making the task of watering easy. Some take the cows to the stable to be milked three times a day, and in this case the watering is done there. During the winter the cows are watered by pumping into the cement manger, or at an indoor watering tank.



WATER SUPPLY FOR TETHERED COWS. INSTEAD OF DRIVING COWS TO WATER THE DANE DRIVES THE WATER TO THE COWS.

The cows are put into the stable in the fall and not let out again until the following spring. They are fed all the straw they will eat, and, on the average, 4 pounds of hay, 40 to 100 pounds of roots, and about 6 pounds of grain per day, consisting of oil cake, bran, barley and oats,—the grain being fed according to the milk flow.

Many of the dairymen on the small farms milk three times a day, having ten cows to the milker. On the large farms they usually milk but twice a day, having from fifteen to twenty cows to the milker, requiring two and one-half hours, night and morning, to do the milking.

MILKING IN DENMARK.

The cows are allowed to go dry from six to eight weeks. To supply the Danish export trade of butter, an even flow of milk is required the year round, and most of the cows freshen from September to May. The male calves and any heifers not needed for future cows are sold for veal at from three to four weeks old. Calves are not allowed to suckle their dams. They are fed whole milk for the first week. After this it is gradually changed to skim milk and this is fed to the heifers until they are four to six months old. From this time on they are raised on pasture during the summer, and in winter are given hay, straw, and roots, and sometimes a little oil cake.

COW TESTING ASSOCIATION

The first coöperative cow testing association was organized in 1895. Later these proved so helpful a factor in weeding out the unprofitable cows, that they have increased rapidly, until at the present time there are about five hundred associations in operation. A man is employed by each association to visit the farms and do the testing every three weeks. He weighs the milk of each cow and keeps an accurate record of the feed consumed, so that at the close of the year the dairyman can determine the net profit per year from each individual cow, and which of his cows are the most efficient producers. By raising the future herd from the best cows the average production has been greatly increased, both in milk and butter fat, and, as would naturally be expected, the yield per one hundred feed units consumed is also greater. This system of feed and milk records has been a prime factor in improving the dairy cattle of Denmark to such a high degree in so few years.

RETURNING FROM MILKING COWS AT TETHER. LABORER'S COTTAGE IN BACKGROUND.

CITY MILK SUPPLY

The question of a pure milk supply for cities was first solved in Denmark when, about 1878, Mr. Busck, an able and philanthropic man, attempted to supply Copenhagen with absolutely reliable milk produced from cows warranted free from tuberculosis. He was assisted by a board of physicians, and established the basis on which the city is now supplied with milk as nearly perfect as can be obtained.

TOWN DAIRYMAN'S HOUSE AND COW STABLE.

The real problem of supplying a large city with milk occurs but a few times in Denmark, so that a brief description of the methods employed by the two large companies of Copenhagen will give an idea of the care taken to secure the proper results. These two companies handle over 100,000 pounds of milk a day, all of which is produced under veterinary inspection and in accordance with strict rules laid down by the company. Inspectors are employed whose duty it is to see that every producer lives up to these rules, which require cleanliness at every step. As soon as drawn, the milk must be cooled and kept below 50° F. until delivered at the bottling plant in Copenhagen. Here it is sampled and tasted,—the slightest off flavor being sufficient to cause its refusal. After passing the inspector and weigh can it is pasteurized at 180° F., cooled to below 50° F. and put into small-necked bottles sealed with corks or expanded pulp covers.

Milk of different standards is sold, but each is distinctly marked with a label stating the quality and price. Milk sold in bulk is sent out in large sealed cans from which it may be drawn only thru a faucet, over which must appear a statement of its quality. In this way skim, one-half skim, whole milk and cream may be put out by the same wagon at prices varying according to the quality without danger of the purchaser being defrauded. But all of this milk is of the same high standard from a sanitary standpoint, as it has all been produced under the same rules, which require the dairymen to provide healthy cows, clean barns and utensils, proper care and feed at all

CITY MILK DELIVERY.

seasons, and, to insure proper cooling thirty pounds of ice must be provided for every eleven gallons of milk produced.

This system of inspection and company control has been brought about largely thru the guidance of the directors who, without remuneration or money interests, serve to see that the supply of milk is as nearly perfect as possible.

MANUFACTURED PRODUCTS

In Denmark dairy manufactures are confined almost exclusively to the making of butter. The first coöperative creamery was started in 1863, but coöperative creameries were not generally successful until after 1880. It was about this time that the centrifugal cream separator came into practical use, and this gave creameries a special impetus and advantage. From this time the dairy industry grew with marvelous rapidity until for several years the production of milk and making it into butter in coöperative creameries has been the chief industry of the country. There are 1100 coöperative and 300 private creameries in Denmark. These manufacture over 200,000,000 pounds of butter a year, eighty percent of which is exported to Great Britain.

COÖPERATIVE CREAMERY.

The milk is hauled to the creameries in large milk wagons which pass along the main roads. Farmers living off these roads bring the milk to the hauler. Some farmers combine with their neighbors and haul the milk themselves. In summer the milk is delivered twice a day and in winter once. Stringent rules are laid down in regard to cooling the milk on the farm and in not mixing morning's and night's milk. All foods which may impart an objectionable flavor to the milk are forbidden. Milk from newly calved cows must not be sent to the creamery until after the fifth day, and milk from diseased cows is prohibited. The creameries are compelled by law to pasteurize all skim milk by heating to 180° F. before it leaves the creamery, to prevent the spread of tuberculosis thru this medium. Penalties are imposed for non-observance of these rules, but the loyalty of the Danes to their own organization makes it rarely, if ever, necessary to inflict these penalties.

REAR VIEW DANISH CREAMERY. MILK CANS ON RECEIVING PLATFORM AT LEFT.

MILK HAULER.

When the Danes decided to make butter for the English market, they of course had a large amount of skim milk as a by-product, and in looking for a way to get the most money out of this, they soon discovered that English bacon was selling at a high price and at once set about converting their surplus skim milk into bacon hogs, and exporting bacon to England with the butter.

A MOTHER OF DANISH BACON.

The creamery buildings are always sanitary and substantial, being constructed of brick, with slate roofs and cement or tile floors. They have a tidy appearance and are surrounded by a lawn kept neatly trimmed and planted with trees, shrubs and flowers.

The machinery used in the creameries is not as convenient or up-to-date as ours. Of the 1400 creameries in Denmark, only 300 have the combined churn and worker,—the remaining 1100 using the old upright Danish churn and table worker. Many of the butter makers still use six or eight old fashioned shot gun cans in which to develop their starter.

The secret of the Danish buttermakers' success lies largely in their habit of thoroness. They first construct a sanitary building and then keep it clean by daily scrubbing. This applies equally well to all the machinery and apparatus in the creamery. In addition to this they have milk delivered to the creamery in almost ideal condition. Another secret of the Danish buttermakers' success is that they study their business thoroly, becoming very proficient, as they expect to remain at this occupation for their life work. Because of this proficiency they turn out a product of uniformly high quality which is the chief factor in their success with an export trade.

DANISH FARMER'S WAGON DELIVERING BACON HOGS AT TRAIN.

WHAT WE MAY LEARN FROM DENMARK

To show the marvelous recent development in Danish dairying it is only necessary to state that the receipts from cows at the present time are seventeen times what they were thirty years ago. From the million dairy cows of Denmark is exported 200,000,000 pounds of butter a year, worth $44,000,000.' At this rate, Illinois, in proportion to her area, would have to export $176,000,000 worth of butter annually.

A LOAD OF DANISH BUTTER FOR EXPORT TO ENGLAND.

With all our boasting about rapid progress and a developed civilization in America, we are a slow people. The Danes owe their rapid rise and marvelous success as a dairy nation to the fact that they were alive to the demands of the markets of the world and strove to meet those offering the greatest remuneration. To secure and hold these, when a practice has been proved of economic value they do not waste a generation or two in adopting and putting it into general use.

The Danish dairyman understands that coöperation is one of the chief underlying principles for the highest success. This attitude is in striking contrast to that of the average American dairyman. Coöperative creameries are frequently pointed to in America as the only thing in which coöperation among farmers has been successful, yet most of our creameries in Illinois started coöperative and in a few years either closed or changed to independent ownership. This shows in a most striking manner the lack of the coöperative, trustful spirit among American dairymen, which has proven of such great value to the dairymen of little Denmark.

The Danes have incorporated in their people the important knowledge that money is not the only thing in life, and that each man owes a duty to his fellows,—that the interests of the community,—yes, the nation—may prosper. This has yet to be instilled in the hearts of many Americans.

The Danes do not have as good a climate or soil as is enjoyed in the Central West. They have small patches of different crops, and cannot take advantage of four-horse teams, large implements and machinery, as can the Americans. They cut much grain by hand, and many of their methods are laborious.

The important question, then, is: How can the Dane afford to import and feed our corn and sell his butter in competition with us? He does this by being a close student of all the principles of dairying. He understands that dairying is an occupation requiring brains, thought and skill; that he must have efficient cows, economically fed and well cared for.

"When such a state of dairy intelligence as is found in Denmark exists among even the American farmers who pretend to be dairymen, there will be less wasting of years of weary, unprofitable toil."—Hoard.

FINAL CONCLUSIONS

It is the history of the world that it is not the largest nations that have done the really great things. In the dairy world it has remained for the little countries of Denmark and Holland to achieve the most economical production of high grade dairy products.

The production of clean milk is what every American dairyman must come to before we can hope to attain for our dairy products the high standard of excellence so conspicuous in the dairy products of Scotland, Holland and Denmark.

In general European dairymen have learned most thoroly that to make money in dairying the first essential is to eliminate every "star boarder" that pulls down the profits, and have a good herd,—a herd in which every individual cow is an economical producer of a high order. They have also learned that these good cows must be well and economically fed and cared for.

The American dairymen should wake up to a full realization of his natural advantages in the cheap feed and good markets, and go at dairying in earnest, realizing that it requires brains, study, and common sense to succeed. He should fit up convenient, substantial, and permanent buildings, and not shift from one phase of agriculture to another, but stay at dairying for a lifetime.

In no country does everything give place to dairying as it does in Denmark and Holland, and in no country in the world are the farmers so prosperous and self respecting.

There is no dairy country, tho the land may be worth $1000 an acre, that has the natural advantages for the production of dairy products enjoyed in the central part of the United States. None of the intensive dairy countries of Europe can produce and preserve in good condition for winter feeding of dairy cows the amount of digestible nutrients per acre that can be secured in the Central West with corn silage and alfalfa hay.

There must be great opportunities ahead of the American dairymen if Denmark can profitably feed our grain and maintain, thru dairy exports, her place as one of the most thrifty nations of the world.

To embrace these opportunities, the American dairyman must realize that the four things practiced in Europe that make the difference between success and failure with the individual and that apply directly to the American dairyman are: a herd of efficient cows; economical feed and care; and clean methods.

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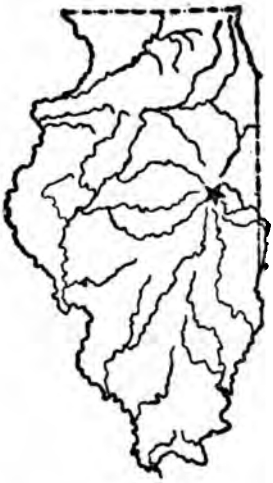
BULLETIN No. 141

RELATIVE EFFICIENCY OF DIFFERENT RATIONS FOR FLESHING HORSES FOR MARKET

By RUFUS C. OBRECHT



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SUMMARY OF BULLETIN No. 141

1. Some of the factors which determine the profits or losses resulting from fleshing horses for market are: The market class and grade selected; their initial cost; their soundness; the cost of feeds; the efficiency of the ration for producing gains; the methods employed in feeding; the length of time necessary to feed to secure the desired finish; the retaining of health and soundness of the horses during the feeding period, and the season marketed. Page 525

2. The object of these experiments was to compare different rations for fleshing horses for market, in which corn, oats, bran, oil meal, clover hay and timothy hay were used; and also, to determine the influence of exercise in taking on of flesh together with methods of stabling. Page 525

3. Plan.—Experiment No. 1 involved three lots of 6 horses each and each lot was fed a different ration for 84 days. Page 526

Experiment No. 2 involved four lots of 6 horses each and each lot was fed a different ration for 112 days. The horses in both experiments were appraised by a committee of experts at the beginning and again at the end of the experiment. Page 539

4. Gains.—The average daily gain per horse in experiment No. 1 varied from 1.88 pounds made by lot 3, to 2.98 pounds made by lot 2. Lot 2 made 30 percent more gains than lot 1, while lot 3 made 18 percent less than lot 1. Page 531

The average daily gain per horse in experiment No. 2 varied from 2.12 to 2.44 pounds made by lots 1 and 3 respectively. Page 543

The largest gain of a single horse in experiment No. 1 was made by No. 11 of lot 2, which gained 297 pounds in 84 days, or an average of 3.54 pounds per day. During the first 28 days he made a daily gain of 4.75 pounds. Page 532

The largest gains in experiment No. 2 was made by No. 48 of lot 2, which gained 363 pounds in 112 days, or an average of 3.24 pounds per day. Page 544

5. Because oil meal is an expensive feed and is used in small amounts with other grains it is very important in horse feeding that only the best quality should be used. Page 541

6. The horses receiving the clover hay in experiment No. 1 had better appetites, making it easier to keep them on feed, drank more water, were in better general thrift, and took on a better market finish than those receiving timothy hay. Page 534

There was no visible difference between the rations in experiment No. 2 so far as the effect on the market condition of the horses was concerned. The horses receiving corn and clover hay did not have as keen an appetite during the latter part of the experiment as those receiving corn, oats and clover hay. The horses receiving corn supplemented with bran and fed with clover hay tired of the bran during the last six weeks. Page 546

7. The horses getting exercise made 41 pounds less gain per head or an average of nearly ½ pound less per day than those not getting exercise. Page 547

8. Seventeen horses in experiment No. 1 made an average gain of 192 pounds, which were worth 25.3 cents per pound, or a total of $48.53. Page 535

Twenty horses in experiment No. 2 made an average gain of 257.7 pounds, which were worth 18 cents per pound, or a total of $46.25. Page 548

9. The cost of producing gains with corn, bran and clover hay in experiment No. 1 was 8.5 cents per pound; with corn, oats, bran and clover hay was 7.4 cents; with corn, oats, bran and timothy hay was 12.1 cents. Page 537

The cost of producing gains with corn and clover hay in experiment No. 2 was 12 cents per pound; with ¾ corn and ¼ oats with clover hay it was 12.3 cents; with one-half oats and one-half corn with clover hay, 12.7 cents; with four-fifths corn and one-fifth bran with clover hay 12.4 cents. Page 549

10. Conclusions..Page 553

RELATIVE EFFICIENCY OF DIFFERENT RATIONS FOR FLESHING HORSES FOR MARKET

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INTRODUCTION

The fleshing of horses for market is a subject that has received but little consideration from investigators altho the business is one of considerable magnitude and importance thruout the middle west. The profits or losses resulting from this industry are determined by a number of factors, some of which are as follows: The market class and grade of horses selected; the initial cost of the horses; their soundness; the cost of feeds; the efficiency of the ration for producing gains; the methods employed in feeding; the length of time necessary to feed to secure the desired finish; the retaining of health and soundness of the horses during the feeding period; and the season when marketed.

It was found that most practical feeders follow the plan of using the feeds they can buy locally and then resorting to condiments, such as stock foods, "black strap" molasses, a cheap grade of brown New Orleans sugar, etc., for keeping up the appetite of their horses. Their opinion as to the efficiency and economy of feeds and appetizers used is most generally based simply upon personal observations. Because of these facts it was thought desirable to determine the relative value of some of the common feeding stuffs used thruout the State of Illinois.

OBJECT OF THE EXPERIMENTS

The main object of these experiments was to secure data for a comparison of rations for feeding horses, as follows: Corn and oil meal; corn, oats, and oil meal; corn, bran, and oil meal; corn, oats, bran, and oil meal; when fed in connection with clover hay, or with timothy hay, with respect to the following points:

1. The rapidity and extent of gains.
2. The economy of gains as measured by feed consumed.
3. The nature of the gains as affecting conformation and ultimately the commercial value.
4. The relative profit to the feeder after considering all items of expense and income.

Another object was to secure data upon the influence of exercise on horses in taking on of flesh together with methods of stabling.

Observations were also made in regard to the individuality of the horses used in the different lots in order to determine, if possible, the type and conformation best suited for feeding purposes; those making the largest gains as well as finishing into the most desirable market animals.

EXPERIMENT NO. 1

PLAN OF THE EXPERIMENT

In planning this experiment it was thought desirable to determine the relative efficiency of timothy hay and clover hay when each was fed in conjunction with corn, oats, bran, and oil meal, for the reason that a majority of farmers consider timothy hay the best roughage for work horses, and it is not uncommon to find some horse feeders using pure timothy or a mixed hay of timothy and clover in fleshing horses for market. A grain ration of corn, bran, and oil meal was also compared with one in which one-half the corn was replaced with oats and in both instances fed in conjunction with clover hay. Briefly stated then, the plan of the experiment was a direct comparison of corn with a mixed ration of corn and oats, and of clover hay with timothy hay, as rations for fleshing horses for market in an eighty-four day feeding period. If the preliminary feeding period were added to the eighty-four days it would make the entire period almost equal to the time usually required to put thin horses into marketable condition, which is from 100 to 120 days.

For convenience, the time was divided into three periods of twenty-eight days each. The initial weights of the horses were secured by weighing them on three consecutive days, and taking the average of the weights. In each instance the horses were weighed after they were fed grain and hay in the morning, but before they were watered. This same plan was carried out in securing the weights at the close of each period of twenty-eight days, the first weights being taken on the day prior, and the last weights on the day subsequent to the dates marking the close of the periods.

At the beginning of the experiment the horses were examined by a committee of expert horsemen, consisting of Mr. L. M. Newgass of the horse commission firm of Newgass & Son, Chicago, Mr. Nels Nelson of Paxton, a local dealer who buys for a Chicago sale stable, and Mr. C. E. Smith of Tuscola, an extensive, experienced feeder of heavy horses and a well known judge. Mr. Smith often consigns finished horses to the Chicago market.

This committee was asked to pass judgment as to the market value of the horses, taking as their standard country prices. They were also asked as to their judgment concerning the uniformity of the lots. This same committee (Mr. Newgass being absent) visited the University again at the close of the experiment and placed values on the horses in their finished form. The committee was asked to take a stationary market as their basis from which to work in order to avoid any unusual conditions that might arise thru market fluctuations and thus it was possible to secure data on the basis of a steady market. From the values assigned to the horses by this committee, all computations are made concerning profits or losses. The writer desires to acknowledge his indebtedness to these gentlemen for their gratuitous services which have been of great value and importance in this experiment.

STABLING AND WATERING

The horses were stabled in the basement of the general stock and storage barn of the University South Farm, which is better lighted and ventilated than the basement of the average barn of this kind. They were tied in single stalls, 4′ 8″ x 9′ and kept there without exercise from the beginning of the experiment until the close, except on weigh days and at a few intervals when it was desirable to have them out for inspection. When weighed they did not walk more than fifteen rods in going to and returning from the scales.

The floor of the stable was paved with brick, with the exception of five stalls, which were earth. The mangers and feed boxes were of the usual kind, built of wood in one end of the stall, and the feed was taken in from the rear, beside the horse. It was originally intended to have water before them in pails at all times but after a short trial it was found that they would very soon befoul it and through their mischievousness, mash the pails.[1] For this reason the plan was abandoned and for a short time they were given water five times daily. They did not drink enough at the second and fourth watering to justify the continuance of this plan, so for the remainder of the test they received water three times daily.

HORSES USED

Eighteen head of horses (five mares and thirteen geldings) were used in this experiment. They were divided into three lots of six horses each, and each horse was tagged with a numbered label. The division was made with the view of securing as nearly as possible uniform lots, considering size, conformation, quality and condition. One of these horses had been on the University farm and was just out of work, while the others were purchased in Central Iowa and Illinois. They were received at the University of Illinois from January 17 to 27, 1906. Nothing was known of the previous treatment or history of the horses, but judging from their appearance, probably most of them had not been stabled during the earlier part of the winter, but perhaps had been given the run of a stalk field and straw stack, which is the treatment often given to farm horses that are not used during the winter; a few, however, showed signs of better care. They were classed as eastern chunks, with two exceptions, these being a little smaller and lighter boned than the others, were classed as farm chunks.

They ranged in age from four to seven years, were sound, of good color (seven grays, seven bays, three browns, and one black), and apparently in good health when they arrived at the University farm. Judging from appearances, they had a greater percentage of Percheron blood than that of any other breed, altho there were evidences of Shire blood in some of them.

PRELIMINARY FEEDING.

The preliminary feeding lasted eleven to twenty-one days, varying according to the time of their arrival at the University. This seemed necessary in order to get the horses accustomed to their new conditions and surroundings, and other matters adjusted. During this time they all received a ration composed of one-half corn, one-half oats, and clover hay. At first they received 12 pounds grain and 14 pounds clover hay per horse daily. Later the hay was increased to 16 pounds per horse daily, which amount they received up to February 6, the beginning of the experiment proper.

It may seem to the experienced feeder that the horses were started on rather heavy grain ration, but this was done because most of the horses had been receiving very liberal feeds of grain for several days before coming to the University; and also because of the practice of most horse feeders not requiring more than a week or ten days to get their horses to consume a maximum grain ration. In this experiment twenty-two to thirty-two days were required, including the preliminary feeding, to get the horses on full feed, or twelve days from the beginning of the experiment proper.

METHODS OF FEEDING AND RATIONS FED

The grain was divided into three feeds daily and given at 6 a. m., 11:30 a. m., and 5 p. m. The grain for each horse was weighed in pails for each feed. After getting the horses on full feed, the quantity of grain fed was determined by the time required for consuming it, and by the avidity of their appetite, they being required to clean up their trough before the next feed was given.

The hay was fed twice daily, morning and evening, and usually in equal amounts. Each feed was weighed separately in bags made for this purpose. They were given all they would consume, but were not allowed to waste any. When they did not consume what was given, it was weighed back and deducted from the amount fed; but this did not often occur.

Anticipating some difficulty in lot 3 (timothy hay horses), it was thought best to introduce some bran and keep salt before them at all times. This was done to avoid danger of colic, since timothy hay is rather constipating when fed with corn and oats to horses not receiving exercise. It was thought salt would stimulate thirst and a liberal consumption of water. This, together with the bran mash, served as a laxative and as a result, in the eighty-four days test only one case of colic occurred in the lot. For the sake of having the results comparable, bran was also introduced into the rations of lots 1 and 2. The quantity of bran fed was largely determined by the amount the horses in lot 3 would readily consume, which at most was 3 pounds daily. Some of the horses in lots 1 and 2 would not consume as much, hence the quantity fed to them was reduced. No. 7 of lot 1, toward the end of the experiment, became so affected by the laxative food that it became necessary to omit the bran mash.

The bran part of the ration was not introduced until a week after the beginning of the experiment, and was given in the form of a wet mash before the noon feed. The grain at this time was reduced in amount, equivalent to the dry bran fed.

Toward the close of the second period it seemed doubtful if the horses would be finished and free from their old hair by the time set to close the experiment. This was especially true with the horses in lot 3. For this reason, it seemed desirable to introduce some oil meal into the ration of all the lots. It was fed during the last period only and the quantity was uniform in all the lots beginning with ½ pound daily per horse, and increasing it to 1 pound per horse for the second week of the period. The third week, it was increased to 1½ pounds and the fourth week to 2 pounds per head daily.

The rations fed were as follows:

Lot 1. Corn, bran, oil meal (old process), clover hay.
Lot 2. Corn, oats, bran, oil meal (old process), clover hay.
Lot 3. Corn, oats, bran, oil meal (old process), timothy hay.

QUALITY AND COST OF FEEDS

The corn was a good quality of shelled No. 2 yellow. The oats were No. 2 white, and of good quality. The bran was of good grade from Minneapolis, Minnesota mills. The oil meal was old process meal, pea size. The clover hay was choice grade and free from dust (medium red variety). The timothy hay graded choice altho the quality was not quite as good as the clover.

The following were prevailing farm prices at the time the experiment was conducted, but other prices have been used showing how it modifies or changes the results.

Corn at 35c per bu. or	$12.50	per ton
Oats at 30c per bu. or	18.75	"
Bran	20.00	"
Oil meal (O. P. pea size)	27.00	"
Clover hay	8.00	"
Timothy hay	9.00	"

HEALTH AND THRIFT OF HORSES

The experiment had been in progress but eighteen days when two of the horses in lot 3, Nos. 17 and 18, had an attack of distemper (strangles). They were immediately isolated from the other horses and none of the others became affected. No. 17 had a light attack while No. 18 had it much more severely, and did not recover in time to continue in the experiment. By the end of the first period No. 17 was again on feed and consuming 14 pounds of corn and oats and 16 pounds of clover. As it was desirable, if possible, to keep her eating and from losing flesh during the attack, clover hay, being more palatable, was substituted for timothy. Because of the doubtful character of No. 17's condition after her sickness and an inequality in the average money values between lots 2 and 3, it was thought best to transfer No. 9 to lot 3 and No. 17 to lot 2. Up to this time No. 9 of lot 2 showed indications of being one of the best feeders, gaining 132 pounds during the first period. On account of the abnormal behavior of Nos. 9 and 17 from this time until the close of the experiment, the data from both these horses was rejected from the final results. In the last two periods No. 9 ate approximately an average amount of feed, but only made a total gain of 40 pounds. In the second and third periods No. 17 ate a little more than an avérage amount of feed and made a total gain of 250 pounds, as much as the average horse of lot 2 made in the three periods. Had No. 17 been fed for twenty-eight days longer, it is fair to suppose that she would have maintained relatively the same ratio of gain as the average horses of lot 2, thus making 90 pounds more, since she always maintained a keen appetite.

No. 13 of lot 1 was also rejected from the final results as he made a total gain of only 80 pounds for the entire time, which is much below the normal. Evidently there must have been something wrong with this horse, as he weighed 10 pounds less at the end of the second period than he did at the beginning of that period. Later he was put on a ration of corn and oats, on which he seemed to thrive somewhat better.

No. 4 of lot 2 also had to be rejected. At the beginning of the third period he bruised his withers from rubbing in the stall and developed a fistula. Up to this time he made more than the average gain for the lot.

TABLE 1. AVERAGE DAILY RATION AND TOTAL FEED PER HORSE (POUNDS)

Lot No.	Feeds	Periods				
		(1) Feb. 6 to Mar. 6, '06 28 days	(2) Mar. 6 to Apr. 3, '06 28 days	(3) Apr. 3 to May 1, '06 28 days	Average Feb. 6 to May 1, '06 84 days	Total feed per horse Feb. 6 to May 1, '06 84 days
Lot 1 (5 horses)	Corn......	16.19	18.1	18.7	17.7	1483.4
	Bran......	2.15	2.8	2.14	2.37	198.7
	Oil meal..	.....	.....	1.23	.....	34.3
	Clover hay	17.16	13.49	10.95	13.86	1164.5
Lot 2 (4 horses)	Corn......	8.03	8.66	9.16	8.62	723.84
	Oats......	8.03	8.66	9.16	8.62	723.84
	Bran......	1.99	2.59	2.66	2.41	202.6
	Oil meal..	.....	.....	1.22	.....	34.1
	Clover hay.	17.00	14.01	10.12	13.73	1153.7
Lot 3 (4 horses)	Corn......	8.06	8.62	8.45	8.38	704.0
	Oats......	8.06	8.62	8.22	8.3	697.1
	Bran......	2.29	2.96	2.51	2.59	217.2
	Oil meal..	.....	.....	1.21	.....	34.0
	Timothy ..	16.92	14.74	12.42	14.69	1234.1

Table 1 gives the average daily ration per horse by periods, for the eighty-four days, and the total feed consumed per horse during the experiment. A careful study of the table will show that all the lots received approximately the same amount of feed daily, the most noticeable difference being in the smaller quantity of hay consumed by lots 1 and 2, which was less during the second and third periods than that of lot 3. While lot 3 consumed the most hay, it also consumed the least grain during the third period.

Table 1 also shows a gradual increase in the amount of grain consumed daily by all the lots. The increase is much more marked, however, in lots 1 and 2 than in lot 3. This was due to the fact that the horses in lots 1 and 2 maintained a much better appetite than those in lot 3 during the latter part of the experiment. Because of this it made it easier to regulate the ration of lots 1 and 2, as there was less danger from over-feeding than there was with lot 3 (the horses getting timothy hay).

TABLE 2. AVERAGE DAILY RATION PER 1000 POUNDS LIVE WEIGHT

Lot No.	Feeds	Periods (1) Feb. 6 to Mar. 6, '06 28 days	Periods (2) Mar. 6 to Apr 3, '06 28 days	Periods (3) Apr. 3 to May 1, '06 28 days	Average for all periods Feb. 6 to May 1, '06 84 days
Lot 1	Corn........	11.64	12.37	12.35	12.25
	Bran........	1.55	1.91	1.41	1.64
	Oil meal.....	.....	.....	.81	.....
	Clover hay...	12.33	9.21	7.23	9.62
Lot 2	Corn........	5.68	5.75	5.82	5.818
	Oats........	5.68	5.75	5.82	5.818
	Bran........	1.41	1.71	1.69	1.628
	Oil meal...	.....	.....	.77	.....
	Clover hay...	12.02	9.30	6.43	9.270
Lot 3	Corn	5.97	6.17	5.85	5.99
	Oats........	5.97	6.17	5.69	5.93
	Bran........	1.70	2.12	1.74	1.85
	Oil meal.....	.....	.....	.84	.....
	Timothy.....	12.54	10.55	8.60	10.51

TABLE 3. AVERAGE WEIGHT AND GAIN PER HORSE BY PERIODS AND TOTAL GAINS

Lot No.	Feeds		Periods (1) Feb. 6 to Mar. 6, '06 28 days	Periods (2) Mar. 6 to Apr. 3, '06 28 days	Periods (3) Apr. 3 to May 1, '06 28 days	Total gain Feb. 6 to May 1, '06 84 days
Lot 1	Corn.....	Wt. at beginning	1345	1437	1491	1345
	Bran.....	Wt. at end.....	1437	1491	1537	1537
	Oil meal..	Lbs. gain.......	92	54	46	192
	Clover ...	Av. daily gain...	3.3	1.9	1.6	2.29
Lot 2	Corn (½).	Wt. at beginning	1356	1472	1540	1356
	Oats (½).	Wt. at end	1472	1540	1606	1606
	Bran.....	Lbs. gain.......	116	68	66	250
	Oil meal..	Av. daily gain...	4.1	2.4	2.4	2.98
	Clover ...	....	....	....	....	....
Lot 3	Corn (½).	Wt. at beginning	1319	1379	1415	1319
	Oats (½)..	Wt. at end	1379	1415	1477	1477
	Bran.....	Lbs. gain.......	60	36	62	158
	Oil meal..	Av. daily gain...	2.14	1.29	2.22	1.88
	Timothy .	....	....	....	....	....

Table 2 gives the average daily ration per thousand pounds live weight. When compared on this basis it will again be seen that lot 3 consumed more hay during the second and third periods than either of the other two lots. Lot 3 consumed nearly as much grain per thousand pounds live weight as lot 1, and slightly more than lot 2. While there was a gradual increase in quantity of grain consumed in the second and third periods, as shown in Table 1, it is interesting to note that the total amount of feed consumed per thousand pounds live weight decreased as the experiment progressed.

Table 3 gives the average weight and gain per horse and the total gains during the experiment. It shows lot 2 to be 11 pounds heavier than lot 1, and 37 pounds heavier than lot 3 at the beginning of the experiment. This inequality in the initial weights between lots 2 and 3 is due largely to the fact that the two horses which were discarded from lot 3 were heavier than the average of the lot.

The most interesting part of this table is that which shows the gains made by the various lots. It will be noticed that the horses of lot 2 made an average gain of 250 pounds, or 58 pounds more than those of lot 1, and 92 pounds more than those of lot 3. Had No. 17 of lot 2 been fed for twenty-eight days longer and we were to add the estimated gain of 90 pounds to the 250 pounds of actual gain made, it would give a total gain of 340 pounds for the eighty-four days. This added to the total gains made by the four horses of lot 2, would give an average gain per horse of 268 pounds. When compared on a percentage basis lot 2 made 30 percent more gain than lot 1 while lot 3 made 18 percent less than lot 1. This helps to emphasize the striking difference in the relative efficiency of the rations of lots 2 and 3 for producing gains.

From these results we must conclude that, so far as gains are concerned, a mixed grain ration of corn and oats is superior to a straight corn ration when fed in conjunction with clover hay; and clover hay is much more valuable than timothy hay when fed in conjunction with corn and oats.

It is also interesting to note the extent of the gains of the various lots as made by periods. In lots 1 and 2, the largest gains were made during the first period, the gains gradually decreasing until the close of the experiment. This was not the case with lot 3, a probable reason for which will be given later. The average daily gain of the horses of lots 1 and 2 is considered very satisfactory, while that of lot 3 is not. The largest gains of any individual horse were made by No. 11 of lot 2 during the first period, in which he gained 133 pounds in twenty-eight days or an average of 4.75 pounds per day. No. 9 of lot 3, which was fed in lot 2 (on corn, oats, bran, and clover hay) for the first period, made a gain of 132 pounds, but in the next two periods, when fed on the same grain and on timothy hay, only made a total gain of 40 pounds, while No. 11, continuing on clover hay during the same time, made 164 pounds gain. Nos. 12 and 16 of lot 3 made the smallest gains of any of the horses in the experiment, an average of 135 pounds for the total time.

TABLE 4. POUNDS OF DRY MATTER PER POUND OF GAIN

Lot No.	Feb. 6 to Mar. 6, '06	Mar. 6 to Apr. 3, '06	Apr. 3 to May 1, '06	Average Feb. 6 to May 1, '06
Lot 1	9.393	15.57	17.61	13.1
Lot 2	7.352	12.21	12.024	9.907
Lot 3	14.332	23.683	12.957	15.923

In Table 4 which gives the pounds of dry matter per pound of gain, it will be noticed that where the gains were small the relative amount of dry matter was large, and that where the gains were large the amount of dry matter was small. This table serves in another way to emphasize the relative efficiency of the ration of lot 2 over that of lots 1 and 3.

TABLE 5. AVERAGE DRY MATTER AND DIGESTIBLE NUTRIENTS PER 1000 POUNDS LIVE WEIGHT PER DAY

Lot No.	Feeds		Periods			
			(1) Feb. 6 to Mar. 6, '06 28 days	(2) Mar. 6 to Apr. 3, '06 28 days	(3) Apr. 3 to May 1, '06 28 days	Average Feb. 6 to May 1, '06 84 days
Lot 1	Corn....	Dry matter.....	22.19	20.51	19.11	20.6
	Bran....	Digest. protein..	1.6	1.51	1.58	1.56
	Oil meal.	" carbohy.	13.04	12.48	11.77	12.43
	Clover ..	" fat......	.917	.835	.889	.88
		Nut. ratio......	1:9.5	1:9.4	1:8.7	1:9.2
Lot 2	Corn (½)	Dry matter.....	21.54	19.68	18.02	19.75
	Oats (½)	Digest. protein..	1.65	1.54	1.61	1.6
	Bran....	" carbohy.	11.67	10.86	9.88	10.80
	Oil meal.	" fat......	.778	.745	.752	.758
	Clover..	Nut. ratio......	1:8.1	1:8.1	1:7.2	1:7.8
Lot 3	Corn (½)	Dry matter.....	22.77	21.8	19.88	21.48
	Oats (½)	Digest. protein..	1.33	1.36	1.45	1.38
	Bran....	" carbohy.	12.26	12.55	11.38	12.06
	Oil meal.	" fat......	.775	.776	.762	.771
	Timothy.	Nut. ratio......	1:10.5	1:10.5	1:9.0	1:10.0

In finding the average dry matter and digestible nutrients consumed per thousand pounds live weight per day by periods, and for the average of all periods, the average weight of the horse was taken. In obtaining this average weight of the horse, the initial weight and final weight of the period, or the experiment, as the case may be, were added and the result divided by two.

By examining Table 5 it will be seen that the average daily dry matter decreases each succeeding period. While lot 2 made the largest total gains, it will be seen they consumed the smallest amount of dry matter per thousand pounds live weight; whereas, lot 3 made the smallest gains and consumed the largest amount of dry matter per thousand pounds live weight. This table also shows that lot 2 received more protein than either of the other lots and a smaller amount of carbohydrates. Lot 3 was the only one in which the total amount of protein received was gradually increased during each period. While lot 3 received more pounds of dry matter per thousand pounds live weight, it also received less digestible nutrients than lot 1, and less digestible protein than either lot 1 or lot 2. It will also be noticed that the nutritive ratio in all the lots gradually narrowed toward the end of the experiment, and was considerably wider in lot 3 than in either of the other lots.

In Table 3 it was shown that lot 3 made slightly more gain in Period 3 than at any other time. They also received more protein during this period and a considerably narrower ration as is shown in Table 5. A reasonable explanation for the increased gain at this time is that these horses in lot 3 had not been receiving enough protein in the ration prior to this to permit of large gains, and with the addition of oil meal gave an increase in protein and also an increase in gain.

A brief review of the matter given indicates that a ration with a nutritive ratio of 1 to 8 is more efficient for producing gains with horses than one with a wider nutritive ratio. For the reason that timothy hay contains a small percent of protein, it is poorly suited as the roughage part of the ration, when fed in conjunction with corn and oats, for producing gains. Since oats contain more digestible protein than corn, and because it adds variety to the ration, it is a valuable adjunct to corn when fed with clover hay. It is fair to presume that it would prove even more valuable when fed with corn and timothy hay.

EFFECT OF RATION ON HORSES

It was noticeable from the beginning of the experiment to the close that the horses receiving the timothy hay never took on the filled appearance and let down in the barrel as did the horses receiving the clover hay. Those receiving the clover hay always had better appetites, making it easier to keep them on feed, drank more water, and were in better general thrift than those receiving timothy hay. The horses receiving clover hay also took on a better market finish. .Those receiving the timothy hay were not well let down in the flank, and did not have that thick covering of flesh necessary to round out their bodies and make them highly appreciated on the market. All the horses, except Nos. 17 and 18, remained in good health thruout the experiment. So far as could be observed, clover hay was not more injurious to the wind of the horses than timothy hay.

Table 6 gives the valuation of the horses at the beginning and at the end of the experiment, based upon a stationary market, as agreed upon by the committee. It also shows the value of gains made to be worth from 19.5 cents to 26.6 cents per pound. The horses of lot 1 were valued $8.00 higher at the beginning of the experiment than those of lot 2, and $16.25 higher than those of lot 3. This inequality of initial valuation is due somewhat to the discarding of some of the horses from the final results. As originally made up. lot 1 had an average valuation of $181.66; lot 2, $176.66; and lot 3, $175.00.

It will be noticed that lot 1 increased in value $51.00 per horse; lot 2, $48.75; and lot 3, $35.00. Lot 1 and lot 2 were nearly enough equal to indicate that the rations of these lots were equally efficient for producing increase in value. The difference is due more to the individuality and sex of the horses than the efficiency of the ration, since lot 1 had one mare and four geldings, while lot 2 had two mares and two geldings. Lot 3, which had three geldings and one mare, was decidedly lacking in finish, and the difference in the relative increased valuation illustrates pretty well what may be expected from the feeding of this ration.

A better basis from which to compute the value of gains is obtained by dividing the average increased valuation of the seventeen horses by the average gain in weight. Referring to the last line of Table 6, it will be seen that the increased valuation per horse was $48.53, the average gain 192 pounds, and the value per pound of increased weight 25.3 cents.

TABLE 6. VALUE OF HORSES ON STATIONARY MARKET

Lot No.	Feeds	No. of horse	Feb. 24, '06 first valuation	May 1, '06 last valuation	Increase in value	Lb. increase in weight	Value per Lb. of increase weight
Lot 1	Corn. . . .	1	$ 215.00	$ 260.00	$ 45.00	. . . .	. . . . .
	Bran. . . .	2	165.00	225.00	60.00	. . . .	. . . . .
	Oil meal.	3	200.00	240.00	40.00	. . . .	. . . . .
	Clover . .	6	190.00	260.00	70.00	. . . .	. . . . .
		5	170.00	210.00	40.00	. . . .	. . . . .
Total . . .			940.00	1195.00	255.00	960	. . . . .
Average			188.00	239.00	51.00	192	26.6c
Lot 2	Corn (½)	2	185.00	220.00	35.00	. . . .	. . . . .
	Oats (½)	15	200.00	265.00	65.00	. . . .	. . . . .
	Bran. . . .	14	150.00	180.00	30.00	. . . .	. . . . .
	Oil meal.	11	185.00	250.00	65.00	. . . .	. . . . .
	Clover . .		. . . . . .	. . . . . .	. . . . .	. . . .	. . . . .
Total . . .			720.00	915.00	195.00	1000	. . . . .
Average			180.00	228.75	48.75	250	19.5c
Lot 3	Corn (½)	12	185.00	200.00	15.00	. . . .	. . . . .
	Oats (½)	8	150.00	200.00	50.00	. . . .	. . . . .
	Bran. . . .	10	165.00	190.00	25.00	. . . .	. . . . .
	Oil meal.	16	175.00	225.00	50.00	. . . .	. . . . .
	Timothy		. . . . . .	. . . . . .	. . . . .	. . . .	. . . . .
Total . . .			675.00	815.00	140.00	630	. . . . .
Average			168.75	203.75	35.00	158	22.2c
Horses not used in expt.		13	150.00	190.00	40.00	80	. . . . .
		9	215.00	235.00	20.00	170	. . . . .
		17	170.00	265.00	95.00	250	. . . . .
		18	160.00	240.00	80.00	170	. . . . .
Total . . .			695.00	930.00	235.00	670	. . . . .
Grand total of all horses . . .			$3030.00	$3855.00	$825.00	3260	. . . . .
Average of 17 horses.			$178.24	$226.76	$48.53	192	25.3c

ITEMIZED FINANCIAL STATEMENT NO. 1
(Per horse)

LOT 1

Expenditures	
To 1 Horse at $188.00	$188.00
" 1483.4 lb. corn at 35c	9.27
" 198.7 lb. bran at $20.00	1.99
" 34.3 lb. oil meal at $27.00	.46
" 1164.5 lb. clover hay at $8.00	4.66
Total expenditures	$204.38
Receipts	
By 1 Horse	$239.00
Profit per horse	$34.62

LOT 2

Expenditures	
To 1 Horse at $180.00	$180.00
" 723.84 lb. corn at 35c	4.52
" 723.84 lb. oats at 30c	6.79
" 202.6 lb. bran at $20.00	2.03
" 34.1 lb. oil meal at $27.00	.46
" 1153.7 lb. clover hay at $8.00	4.61
Total expenditures	$198.41
Receipts	
By 1 Horse	$228.75
Profit per horse	$30.34

LOT 3

Expenditures	
To 1 Horse at $168.75	$168.75
" 704 lb. corn at 35c	4.40
" 697.1 lb. oats at 30c	6.54
" 217.2 lb. bran at $20.00	2.17
" 34 lb. oil meal at $27.00	.46
" 1234.1 lb. timothy hay at $9.00	5.55
Total expenditures	$187.87
Receipts	
By 1 Horse	$203.75
Profit per horse	$15.88

From financial statement No. 1, it will be seen that lot 1 netted the largest profit, being $4.28 more per horse than lot 2, and $18.74 more than lot 3. Results arrived at in this way might be accurate enough had a large number of animals been used in each lot. In this test, the number in each lot was too small, for the valuation of horses can only be approximated because we do not have an accurate standard from which to measure values, such as prevails in markets for cattle, hogs and sheep.

It is shown by the data taken from Table 6 that for an average of seventeen horses, the gains made were worth 25.3 cents per pound.

This factor should be fairly accurate because of the number of horses involved.

FINANCIAL STATEMENT No. 2

(Profit per horse based on pounds of gain)

LOT 1

Expenditures	
To 1483.4 lb. corn at 35c	$ 9.27
" 198.7 lb. bran at $20.00	1.99
" 34.3 lb. oil meal at $27.00	.46
" 1164.5 lb. clover hay at $8.00	4.66
Total cost of feed	$ 16.38
Receipts	
By 192 lb. gain at 25.3c	$ 48.58
Profit per horse	$ 32.20
Cost per pound gain	8.5 cents

LOT 2

Expenditures	
To 723.84 lb. corn at 35c	$ 4.52
" 723.84 lb. oats at 30c	6.79
" 202.6 lb. bran at $20.00	2.03
" 34.1 lb. oil meal at $27.00	.46
" 1153.7 lb. clover hay at $8.00	4.61
Total cost of feed	$ 18.41
Receipts	
By 250 lb. gain at 25.3c	$ 63.25
Profit per horse	$ 44.84
Cost per pound gain	7.4 cents

LOT 3

Expenditures	
To 704 lb. corn at 35c	$ 4.40
" 697.1 lb. oats at 30c	6.54
" 217.2 lb. bran at $20.00	2.17
" 34 lb. oil meal at $27.00	.46
" 1234.1 lb. timothy hay at $9.00	5.55
Total cost of feed	$ 19.12
Receipts	
By 158 lb. gain at 25.3c	$ 39.97
Profit per horse	$ 20.85
Cost per pound gain	12.1 cents

A brief consideration of financial statement No. 2 will show that when taken from the standpoint of gains, which is done in order to eliminate individuality, the ration fed lot 2 yielded a larger profit than that fed either of the other lots. While lot 2 gave the largest profits, based on pounds gain, it was also a more expensive ration than that fed lot 1, but not so expensive as that fed lot 3. The cost per pound gain made by lot 2 was less than either of the other lots due to the efficiency of the ration to produce larger gains. The cost per pound gain made by lot 1 was 8.5 cents; lot 2, 7.4 cents; and lot 3, 12.1 cents, or 63 percent greater than that of lot 2.

No account has been taken of the labor involved in caring for the horses nor the bedding used. It has been assumed that the manure produced would offset this item of expense.

TABLE 7. NET PROFIT PER HORSE AND COST PER POUND OF GAIN WITH VARYING PRICES OF FEEDS

Feeds used and at varying prices	With increase gain at 25.3c per lb.	Lot 1	Lot 2	Lot 3
		Corn Bran Oilmeal Clover	Corn (½) Oats (½) Bran Oil meal Clover	Corn (½) Oats (½) Bran Oilmeal Timothy
Corn at 35c, oats at 30c, bran at $20.00 per ton, oil meal at $27.00 per ton, clover hay at $8.00 per ton, timothy hay at $9.00 per ton.	Net profit. . . .	$32.39	$45.09	$21.01
	Cost per pound of gain.	8.5c	7.4c	12.1c
Corn at 40c, oats at 35c, bran at $22.00 per ton, oil meal at $30.00 per ton, clover hay at $8.00 per ton, timothy hay at $9.00 per ton.	Net profit	$30.82	$43.06	$19.02
	Cost per pound of gain.	9.3c	8.2c	13.4c
Corn at 50c, oats at 45c, bran at $24.00 per ton, oil meal at $30.00 per ton, clover hay at $8.00 per ton, timothy hay at $9.00 per ton.	Net profit.	$27.97	$39.31	$15.37
	Cost per pound of gain.	10.8c	9.7c	15.7c
Corn at 65c, oats at 55c, bran at $26.00 per ton, oil meal at $32.00 per ton, clover hay at $11.00 per ton, timothy hay at $12.00 per ton.	Net profit.	$22.02	$33.15	$ 9.22
	Cost per pound of gain.	13.9c	12.4c	20.0c

It will be seen from Table 7, which gives the net profit per horse and cost per pound of gain with varying prices of feeds, that in every instance lot 2 would return the largest profit and make cheaper gains than any other lot.

With corn at 50 cents, oats at 45 cents and bran at $24.00 per ton, there is still a nice profit to be made as is shown in the above statement. With such conditions, lot 2 would return $11.34 or 41 percent more profit per horse than lot 1, and $23.94 or 155 percent more profit per horse than lot 3. The higher in price the grain, the more profitable relatively would be the ration fed lot 2 because of its greater efficiency to produce gains than that fed lots 1 and 3. Even under such conditions, the rations fed all the lots would prove profitable, for it will be seen that lot 3, which received the least efficient ration, produced gains at a cost less than their value when produced.

EXPERIMENT NO. 2

PLAN OF THE EXPERIMENT

This experiment was planned to secure more data upon the results of mixing oats and bran with corn as compared with an all-corn ration, with clover hay as the roughage in each instance.

A comparison was also made of the effect of exercise with no exercise upon the taking on of flesh; some of the horses were given a walk of 2.8 miles daily, while others were kept in the barn without any exercise. Horses allowed the freedom of a box stall were also compared with others tied in single stalls without exercise.

The experiment extended over 112 days or four periods of 28 days each. The initial and final weights of each period were secured by taking the average of three consecutive daily weights, the same plan being used as in the previous experiment. The horses were appraised at the beginning and at the end of the experiment by a committee of expert horsemen. At the beginning of the experiment, the committee was composed of Messrs. T. V. Coffin of Champaign, Illinois, an extensive feeder and dealer in heavy horses, and Dan Sayer of the commission firm of E. H. Schloeman and Co., Chicago. It was intended to have the same committee do the appraising at the close of the experiment, but it was impossible to get the services of Mr. Sayer at that time and so Henry Piosa of the same firm substituted for him.

STABLING AND WATERING

The horses were stabled in the basement of the general stock and storage barn of the University South Farm, which is described under the above head in Experiment No. 1. Half, or 12 of the horses were tied in single stalls and the others were turned loose in box stalls about 12 x 14 feet. They were watered three times daily from pails, and given all the salt they would consume by keeping a small box of it in front of each horse.

HORSES USED

Twenty-four head of geldings varying in age from four to eight years were used in this experiment, and were divided into lots of six horses each. The horses were divided into as nearly uniform lots as possible considering size, conformation, age, quality, condition, and valuation. It will be seen that at the beginning of the experiment, lot 4 was about 40 pounds heavier than lots 2 and 3, and 66 pounds heavier than lot 1. The greater weight was due to size and ruggedness rather than better flesh. Each horse was given a number for identification, which was branded on his left front hoof.

They were native horses, just out of work, and were purchased from local dealers in central Illinois except two of the geldings, which had been used on the University Farm for more than two years. Most of them showed evidences of Percheron or Shire breeding tho a few had the characteristics of Belgian blood. Commercially they would have been rated on the market from "good" to "choice," and most of them classed as light draft, while a few were eastern chunks. On the whole the horses used in this experiment were larger, better and more uniform than those used in the first experiment. When they arrived at the University, all of them were sound except one horse, which had a hip slightly down. Later some of them became injured, but at the end of the experiment they were appraised as sound in order to arrive at the value of the flesh taken on.

They were received at the University from September 15 to September 24, 1906, and were turned on rather short pasture without grain, excepting a small amount of green corn cut daily from the field. They remained out on pasture until October 18 when they were taken up and put into the barn preparatory to beginning the experiment.

It was not the intention to have the horses gain much while on pasture, but simply hold their own. The real purpose in putting the horses on pasture was not to secure gains but to tone up their systems and give all an equal chance when started on feed. It was thought that the above method would do it, but for some unaccountable reason they did not seem to thrive well for a month or more after being put into the barn. The writer thinks the trouble was in the pasture, for on the same farm similar difficulties have been experienced with broodmares and colts during the late summer and autumn months. It is believed that greater gains would have been secured had they never been turned onto pasture.

PRELIMINARY FEEDING

The preliminary feeding extended over a period of six days, the time considered necessary to accustom the horses to their new environment and get things adjusted for beginning the experiment proper. During this time they all received a ration of corn and clover hay, beginning with 12 pounds of grain and 16 pounds of hay daily, and gradually increasing the hay to 24 pounds daily.

METHODS OF FEEDING AND RATIONS FED

As in the previous experiment, the grain fed was divided into three feeds daily and given at 6 a.m., 11:30 a.m., and 5 p.m. The horses were not given a maximum grain ration until six weeks after the beginning of the experiment, the time being somewhat longer than in the previous test. From the beginning they were fed all the hay they would eat up clean, and the quantity gradually grew less as the grain was increased. The hay was fed twice daily, morning and evening and usually in equal amounts. All foreign matter such as corn stalks and waste hay (which only rarely occurred), was collected, weighed back, and deducted from the amount fed. Where a mixed grain ration was fed, a weighed quantity of the feed was prepared in the proper proportions and placed in a bin from which the feeding was done, and likewise a quantity of corn for lot 1. During the closing period of the experiment, a small quantity of oil meal was fed to put the hair in good condition. The rations fed were as follows:

Lot 1. Corn, oil meal (old process), clover hay.
Lot 2. Corn ¾, oats ¼, oil meal (old process), clover hay.
Lot 3. Corn ½, oats ½, oil meal (old process), clover hay.
Lot 4. Corn ⅘, bran ⅕, oil meal (old process), clover hay.

QUALITY AND COST OF FEEDS

The quality of the feeds used was the same as described in Experiment No. 1. The following were about the average farm prices of the feeds during the time when the experiment was conducted:

Corn at 43c per bu. or	$15.36	per ton
Oats at 35c per bu. or	21.88	per ton
Bran at $1.00 per cwt. or	20.00	per ton
Oil meal (O. P. pea size) at	27.00	per ton
Clover hay at	13.00	per ton

It will be noted that clover hay was excessively high, owing to the shortage of the crop. Other prices will be used in comparison with the above in order to show the results when the prices of feeds are varied.

HEALTH AND THRIFT OF HORSES

As stated earlier, this experiment did not start off satisfactorily for some unaccountable reason. The data from three horses in the experiment were rejected (No. 33, lot 1, No. 37, lot 2, and No. 41, lot 4), because they did not thrive, and their gains were so small they were considered abnormal. There was nothing to indicate that these horses would not be good feeders but they failed to respond to the feed consumed. As it happened, lots 1, 3 and 4 each contained one of these unthrifty horses, while in lot 2 No. 36 died two and one-half months after the experiment began. A post-mortem examination failed to reveal the cause of the trouble, which was in the head and rendered breathing so difficult that a trachea tube was necessary to keep the horse alive for even a few hours. Up to this time No. 36 had been making more than average gains. The death of this horse and the rejection of three others left five horses in each lot. Horse No. 25 of lot 1 had a few attacks of colic which may have slightly prevented his making larger gains. He was below average in this respect, but the feeding of a heavy ration of whole corn may be partly accountable for the colic. All the other horses remained in good health, but during the third period they all received a set back caused by attempting to introduce some oil meal so unpalatable to them that they would not consume their grain when the oil meal was added. The following tables show the reduction in the amount of feed consumed at this time.

So far as was possible to observe, the horses not having exercise remained in as good health as those getting the daily walk of 2.8 miles.

From a study of Table 8 it will be seen that lot 1 ate less grain and hay than the other lots, while lot 4 ate slightly less hay than that consumed by lots 2 and 3. The table also shows a gradual increase in the amount of grain consumed in the first two periods and a falling off in all lots during the third period. This reduction is due to an attempt to introduce oil meal about the middle of the third period which caused all the horses to go off feed. After continued efforts to induce the horses to eat it in small quantities mixed with the regular grain ration, most of them became so averse to it that they would leave their grain when the oil meal was added. It is not known why the horses disliked it unless it was new process meal. The stock of meal was new and not repulsive to cattle, nor did it seem objectionable to taste or smell. After about ten days some new oil meal was provided which was relished by the horses during the last or fourth period, when the grain was again materially increased.

The table shows the hay consumed was largest during the first period from which time it was gradually reduced up to the last or fourth period when it was again increased. It will be noted that the relative amount of bran was also reduced in lot 4 during the third and fourth periods. This was necessary owing to the fact that all of the horses of this lot showed signs of not relishing the bran before the end of the experiment, while some of them tired of it to the extent that they would refuse their corn when it was mixed with the normal amount of bran. By studying Table 9, which gives the average daily ration per thousand pounds live weight, it will be seen that when the different lots are compared on this basis there is less marked difference in the quantity of feed consumed than there appears to be in Table 8. The averages for all periods show that lot 3 used slightly more grain and hay per thousand pounds live weight than the other lots. In general, it will be seen that here, as in the previous experiment, tho not so marked, the total amount of feed consumed per thousand pounds of live weight decreased as the experiment progressed.

TABLE 8. AVERAGE DAILY RATION AND TOTAL FEED PER HORSE (POUNDS).

Lot No.	Feeds	Periods				Average for all periods 112 days	Total feed per horse Oct. 24, '06 to Feb. 13, '07 112 days
		(1) Oct. 24 to Nov. 21, '06 28 days	(2) Nov. 21 to Dec. 19, '06 28 days	(3) Dec. 19 to Jan. 16, '07 28 days	(4) Jan. 16 to Feb. 13, '07 28 days		
Lot 1 (5 horses)	Corn.......	15.5	20.1	15.2	17.5	17.07	1911.6
	Oil meal....	.....	.....	.....	1.07	.27	30.
	Clover hay..	22.3	18.9	15.7	17.2	18.53	2075.2
	Total......	37.8	39.0	30.9	35.77	35.87	4016.8
Lot 2 (5 horses)	Corn.......	11.8	15.8	14.6	14.95	14.29	1599.97
	Oats.......	3.9	5.3	4.9	5.0	4.76	533.3
	Oil meal....	.....	.....	.....	1.25	.....	35.
	Clover hay..	23.6	21.7	15.5	16.46	19.3	2162.3
	Total......	39.3	42.8	35.0	37.66	38.35	4330.57
Lot 3 (5 horses)	Corn.......	7.87	10.5	9.6	10.5	9.62	1077.1
	Oats.......	7.87	10.5	9.6	10.5	9.62	1077.1
	Oil meal....	.....	.....	.....	1.2	.....	33.5
	Clover hay..	23.2	21.4	16.5	17.2	19.59	2194.1
	Total......	38.94	42.4	35.7	39.4	38.83	4381.8
Lot 4 (5 horses)	Corn.......	12.6	15.96	15.7	20.3	16.14	1807.7
	Bran.......	3.1	4.0	3.4	2.0	3.14	351.5
	Oil meal....	.....	.....	.....	1.2	.....	34.8
	Clover hay..	22.9	18.8	15.4	17.2	18.58	2080.8
	Total......	38.6	38.76	34.5	40.7	37.86	4274.8

TABLE 9. DAILY RATION PER 1000 POUNDS LIVE WEIGHT

Lot No.	Feeds	Periods				Average for all periods Oct. 24, '06 to Feb. 13, '07 112 days
		(1) Oct. 24 to Nov. 21, '06 28 days	(2) Nov. 21 to Dec. 19, '06 28 days	(3) Dec. 19 to Jan. 16, '07 28 days	(4) Jan. 16 to Feb. 13, '07 28 days	
Lot 1	Corn.....	10.54	13.07	9.5	10.59	10.98
	Oil meal..	.....	.....	.....	.65	.....
	Clover hay	15.23	12.27	9.79	10.44	11.92
	Total....	25.77	25.34	19.29	21.68	23.08
Lot 2	Corn.....	7.79	9.93	8.89	8.79	8.92
	Oats.....	2.59	3.31	2.96	2.93	2.97
	Oil meal..	.....	.....	.....	.73	.....
	Clover hay	15.56	13.63	9.45	9.69	12.05
	Total....	25.94	26.87	21.30	22.14	23.94
Lot 3	Corn.....	5.2	6.56	5.82	6.17	6.01
	Oats.....	5.2	6.56	5.82	6.17	6.01
	Oil meal..	.....	.....	.....	.69	.....
	Clover hay	15.33	13.38	10.00	10.11	12.24
	Total....	25.73	26.50	21.64	23.14	24.26
Lot 4	Corn.....	8.20	9.98	9.47	11.84	9.91
	Bran.....	2.05	2.49	2.08	1.15	1.93
	Oil meal..	.....	.....	.....	.72	.....
	Clover hay	14.93	11.77	9.32	9.98	11.41
	Total....	25.18	24.24	20.87	23.69	23.25

TABLE 10. AVERAGE WEIGHT AND GAIN PER HORSE BY PERIODS, AND TOTAL GAINS

Lot No.	Feeds		Periods				Total gain Oct. 24, '06 to Feb. 13, '07 112 days
			(1) Oct. 24 to Nov. 21, '06 28 days	(2) Nov. 21 to Dec. 19, '06 28 days	(3) Dec. 19 to Jan. 16, '07 28 days	(4) Jan. 16 to Feb. 13, '07 28 days	
Lot 1	Corn.....	Wt. at beginning.	1436	1499	1576	1629	1436
	Oil meal..	" " end......	1499	1576	1629	1674	1674
	Clover...	Pounds gain.....	63	77	53	45	238
		Av. daily gain....	2.25	2.75	1.89	1.61	2.12
Lot 2	Corn (3/4).	Wt. at beginning.	1468	1563	1620	1664	1468
	Oats (1/4)	" " end......	1563	1620	1664	1734	1734
	Oil meal..	Pounds gain.....	95	57	44	70	266
	Clover...	Av. daily gain....	3.39	2.04	1.57	2.50	2.38
Lot 3	Corn (1/2).	Wt. at beginning.	1463	1564	1635	1671	1463
	Oats (1/2)	" " end......	1564	1635	1671	1736	1736
	Oil meal..	Pounds gain.....	101	71	36	65	273
	Clover...	Av. daily gain....	3.61	2.54	1.29	2.32	2.44
Lot 4	Corn (4/5).	Wt. at beginning.	1502	1569	1630	1681	1502
	Bran (1/5).	" " end......	1569	1630	1681	1755	1755
	Oil meal..	Pounds gain.....	67	61	51	74	254
	Clover...	Av. daily gain....	2.39	2.18	1.82	2.64	2.26

A perusal of Table 10 shows lot one to be slightly lighter than lots 2 and 3, all of which were lighter than lot 4 at the beginning of the experiment. It did not seem possible to get the lots more evenly divided in weight without unbalancing the quality, which was wholly undesirable. The various lots seemed equal with regard to the amount of flesh that each might take on.

The horses in lot 3 made an average gain of 273 pounds, which is 7 pounds more than made by lot 2, 19 pounds more than lot 4, and 35 pounds more than made by lot 1. It will also be noticed that the highest average daily gain is 2.44 pounds, which is less than the best in Experiment 1, and not altogether satisfactory. However, the small gains may be accounted for in several ways: The horses did not start off feeding well from the first; later they were off feed for ten days due to an attempt to introduce into the ration oil meal, which they would not eat, and it will be noted that some of the horses in each lot were exercised daily and did not make as large gains as those not exercised. (See Table 13, page 546.)

From these results, we must conclude that a ration of corn supplemented with oats and fed in conjunction with clover hay is superior to an all-corn ration for producing gains tho the extent of gains is little influenced when the quantity of oats is not less than one-fourth and not more than one-half of the grain fed; and also, that a small quantity of bran mixed with corn and fed in conjunction with clover hay is superior to an all-corn ration for producing gains tho not as good as a mixed ration of corn and oats.

Lot 1 made its greatest gain during the second period, lots 2 and 3 made their greatest gain during the first period, while lot 4 made its greatest gain during the fourth period. No. 48 in lot 2 made an average daily gain of 3.24 pounds, or a total gain of 363 pounds in the 112 days, which was larger than that made by any other horse in the experiment.

TABLE 11. POUNDS OF DRY MATTER PER POUND OF GAIN

Lot No.	Periods				Average Oct. 24, '06 to Feb. 13, '07
	(1) Oct. 24 to Nov. 21, '06	(2) Nov. 21 to Dec. 19, '06	(3) Dec. 19 to Jan. 16, '07	(4) Jan. 16 to Feb. 13, '07	
Lot 1........	14.53	12.32	14.19	19.38	14.66
Lot 2........	10.01	18.24	19.39	13.13	14.15
Lot 3........	9.33	14.51	24.22	14.81	13.95
Lot 4........	13.97	15.48	16.52	13.44	14.64

The economic use made of the feeds is brought out in Table 11, which shows lot 3 to have required the least dry matter to make a pound of gain; lot 2 is next in order, then lots 4 and 1, which are about the same. This helps to emphasize the fact that perhaps the rations of lots 2 and 3 were more palatable than that of lots 1 and 4, and with the result that a larger amount of feed was consumed and larger and more economical gains secured. It will also be seen that the amount of dry matter per pound of gain is higher than that required in lots 1 and 2 in Experiment 1.

Table 12 gives the average daily dry matter and digestible nutrients per thousand pounds live weight, which shows that the amount of dry matter decreased as the experiment progressed and was noticeably less during the third and fourth periods.

In the average for the entire experiment lot 1 received slightly less dry matter than lot 4, and noticeably less than lot 2. Lot 3 consumed the largest amount of dry matter per thousand pounds live weight, and also made larger gains than any other lot in the experiment. The relative amount of gains made in the other lots is in the same proportion as the amount of dry matter consumed per thousand pounds live weight.

Table 12 also shows that lot 3, which made the largest gains, received the largest amount of digestible protein and the smallest amount of carbohydrate of all the lots, while lot 1, which received the smallest amount of digestible protein and next to the largest amount of digestible carbohydrates made the smallest gains of all the lots. In other words, this indicates that a ration with a nutritive ratio of 1 : 9.5 is too wide for best results in fleshing horses. We see here, as in Experiment 1, that the narrower the nutritive ratio, the larger the gains. Lot 4, however, is an exception; as will be seen it was fed a slightly narrower nutritive ratio than lot 2 and made 12 pounds less gain. This difference is so small that it is more likely to be due to the individuality of the horses than to the ration fed. It will also be seen that the nutritive ratio gradually widened in all lots until the

TABLE 12. AVERAGE DRY MATTER AND DIGESTIBLE NUTRIENTS PER 1000 POUNDS LIVE WEIGHT PER DAY

Lot No.	Feeds		Periods				Total Oct. 24, '06, to Feb. 13, '07 112 days
			(1) Oct. 24 to Nov. 21, '06 28 days	(2) Nov. 21 to Dec. 19, '06 28 days	(3) Dec. 19 to Jan. 16, '07 28 days	(4) Jan. 16 to Feb. 13, '07 28 days	
	Corn	Dry matter.	22.16	22.04	16.76	18.87	19.96
Lot 1	Oil meal. .	Digest. protein . .	1.54	1.55	1.17	1.46	1.43
	Clover . . .	" carbohyd.	12.77	13.32	10.02	11.19	11.83
		" eth. extr .	.79	.87	.65	.76	.77
		Nut. ratio	1:9.5	1:9.9	1:9.9	1:8.8	1:9.5
	Corn (¾).	Dry matter.	22.42	23.34	18.56	19.32	20.91
Lot 2	Oats (¼)	Digest. protein . .	1.58	1.68	1.36	1.57	1.55
	Oil meal .	" carbohyd.	12.33	13.36	10.91	11.17	11.94
	Clover . . .	" eth. extr. .	.77	.88	.73	.78	.79
		Nut. ratio	1:8.9	1:9.1	1:8.3	1:8.3	1:8.9
	Corn (½).	Dry matter.	22.25	23.01	18.84	20.19	21.07
Lot 3	Oats (½)	Digest. protein . .	1.61	1.71	1.42	1.67	1.60
	Oil meal .	" carbohyd.	11.80	12.61	10.47	11.14	11.50
	Clover . . .	" eth. extr. .	.75	.84	.71	.79	.77
		Nut. ratio	1:8.3	1:8.4	1:8.5	17.7	1:8.2
	Corn (⅘).	Dry matter.	21.76	21.08	18.18	20.68	20.42
Lot 4	Bran (⅕).	Digest. protein . .	1.57	1.57	1.36	1.66	1.54
	Oil meal. .	" carbohyd.	11.96	12.12	10.67	12.34	11.68
	Clover . . .	" eth. extr. .	.73	.78	.69	.85	.76
		Nut. ratio	1:8.7	1:8.8	1:9	1:8.6	1:8.8

last period, where it is perceptibly narrower, due to the feeding of oil meal. The nutritive ratio gradually widened at first due to the fact that the horses ate less clover hay and more grain as the experiment progressed. The small amount of nutrients fed during the third period is due to the horses being off feed for about ten days at the time when an attempt was made to introduce poor oil meal.

Table 10 shows the gains made in lots 2, 3 and 4 to be less during the second period than during the first period, and still less during the third period than during the second period. During the last or fourth period the gains are increased over those of the third period. This helps to emphasize the fact again that as the experiment progressed and the nutritive ratio became wider, the gains decreased until the last period when oil meal was introduced making a narrower nutritive ratio when they again increased. The behavior of lot 1 was abnormal in this respect, the reason for which is unaccountable.

A brief review of the results obtained in this experiment seem to justify some of the conclusions reached in Experiment 1, that a ration with a nutritive ratio of 1:8 is more satisfactory for producing gains in fleshing horses than one with a wider nutritive ratio.

So far as the effect on the market condition of the horses was concerned, there was no visible difference between the rations. The horses in lot 1, receiving corn and clover hay, did not have as keen an appetite during the latter part of the experiment as those of lots 2 and 3, which received corn, oats and clover hay. The horses in lot 4, receiving corn, bran and clover hay, ate nearly as much as those of lots 2 and 3, but during the last six weeks of the experiment it was easy to see that they were becoming tired of the bran, and consequently the proportion had to be reduced from 1/5 to whatever amount they would consume, which with some of the horses was almost nothing, while others would take ¼ the entire amount of grain fed.

EFFECT OF EXERCISE

The effect of exercise upon the taking on of flesh is shown in the following table:

TABLE 13. EXERCISE *vs.* NO EXERCISE

Kind of treatment	Number of horses	Weight, Lb., Oct. 24, '06	Weight, Lb., Jan. 16, '07	Av. gain Lb., 84 days	Average daily gain, Lb.
Exercise	7	1507	1675	168	2
No exercise	13	1446	1655	209	2.49

The horses getting exercise were walked 2.8 miles daily for a period of 84 days from the first of the experiment. Eight horses were given this exercise daily, but only seven are included in the average as one horse was rejected as being abnormal in that he made a very slight gain. There were sixteen horses which did not get exercise, two of which were rejected owing to the fact that they did not thrive, and another one died, leaving only 13 horses from which the average has been computed. As much care as possible was used in making the selection of horses with which to test the effect of exercise. Half of them were stabled in box stalls and the other half in single stalls and tied up. Two horses from each lot were selected for exercise, one from a box stall and another from a single stall. This left twice as many to remain in the barn without exercise. Because the roads were bad from being very muddy or frozen and very rough, the exercise was discontinued at the end of the third period.

In Table 13, it will be seen that the horses getting exercise made 41 pounds less gain per head or an average of nearly ½ pound less per day than those not getting exercise. So far as could be observed, the horses not having exercise remained in as good health and retained their appetite as well as those given exercise. It was not possible to follow these horses up after they were marketed in order to see what the ultimate results would be, as many of them were purchased by dealers on the market and taken to different parts of the country.

EFFECT OF BOX STALL

As stated above, one-half of the horses were stabled loose in box stalls, while the other half were tied in single stalls where no exercise could be taken.

The following table gives the results of this test:

TABLE 14. SINGLE STALL *vs.* BOX STALL

Kind of stall	Number of horses	Weight, Lb., Oct. 24, '06	Weight, Lb., Jan. 16, '07	Av. gain, Lb., 84 days	Daily gain, Lb.
Single stall........	10	1454	1656	202	2.4
Box stall..........	10	1481	1667	186	2.2

From the above table, it will be seen that the horses tied up in the single stalls made better gains by .2 pound per day than those having the freedom of box stalls. This illustrates again the detrimental effect of exercise upon the taking on of flesh. It has been claimed by some men that the box stall offers an advantage in helping to prevent bog spavins and thoroughpins. The writer could detect no difference in favor of the box stall in this regard. It does help, however, to prevent accidents, as horses are not so likely to become injured from being kicked by adjoining stall companions. The box stall has the disadvantage of being more expensive in its initial cost and requires more room so that fewer horses can be accommodated, which is often an important item. The labor involved in caring for the horses is also greater where the box stall is used.

Table 15 gives individual gains, and shows that the horses in single stalls made greater gains in 84 days than those in box stalls, in both instances, where they received exercise and with no exercise. The evidence shown here in favor of the single stall where the horses received exercise is not sufficient to be conclusive, as too few horses were involved, but it does seem to corroborate the results obtained with a larger number of animals including the horses receiving no exercise. It would seem safe to conclude that there is nothing to be gained by the use of the box stall so far as it may influence the horse in taking on flesh.

The valuation of the individual horses at the beginning and end of the experiment as assigned by the appraising committee, based

TABLE 15. INDIVIDUAL GAINS MADE BY HORSES IN 84 DAYS (POUNDS)

Lot No.	Exercise			No exercise		
	Horse No.	Single stall	Box stall	Horse No.	Single stall	Box stall
Lot 1	30	. . .	116	22	. . .	225
	. .	. . .	. . .	25	. . .	120
	. .	. . .	. . .	27	280	. . .
	. .	. . .	. . .	32	224	. . .
Lot 2	28	. . .	183	24	. . .	211
	46	189	. . .	43	130	. . .
	. .	. . .	. . .	48	. . .	270
Lot 3	38	. . .	133	35	254	. . .
	23	188	. . .	42	. . .	253
	. .	. . .	. . .	49	213	. . .
Lot 4	31	172	. . .	34	177	. . .
	39	. . .	193	44	. . .	159
	. .	. . .	. . .	47	198	. . .
Total.		549	625		1476	1238
Average.		183	156		211	206

TABLE 16. APPRAISED VALUATION OF HORSES

Lot No.	Feeds	No. of horse	First valuation	Last valuation	Increas'd valuation	Lb. increase in weight	Value per lb. of increased wt.
Lot 1	Corn.	22	$235.00	$275.00	$40.00	. . .	. . . . .
	Oil meal. . . .	25	210.00	210.00	. . . . .	. . .	. . . . .
	Clover.	27	215.00	300.00	85.00	. . .	. . . . .
		30	215.00	275.00	60.00	. . .	. . . . .
		32	185.00	220.00	35.00	. . .	. . . . .
		Av . . .	212.00	256.00	44.00	238	18.5c
Lot 2	Corn (¾) . .	24	235.00	290.00	55.00	. . .	. . . . .
	Oats (¼) . .	28	200.00	255.00	55.00	. . .	. . . . .
	Oil meal . .	43	235.00	250.00	15.00	. . .	. . . . .
	Clover	46	225.00	275.00	50.00	. . .	. . . . .
		48	200.00	280.00	80.00	. . .	. . . . .
		Av . . .	219.00	270.00	51.00	266	19.2c
Lot 3	Corn (½) . .	23	240.00	235.00	-5.00	. . .	. . . . .
	Oats (½) . .	35	210.00	255.00	45.00	. . .	. . . . .
	Oil meal. . . .	38	185.00	235.00	50.00	. . .	. . . . .
	Clover	42	235.00	310.00	75.00	. . .	. . . . .
		49	215.00	260.00	45.00	. . .	. . . . .
		Av . . .	217.00	259.00	42.00	273	15.4c
Lot 4	Corn (4/5) .	31	225.00	265.00	40.00	. . .	. . . . .
	Bran (1/5) .	34	225.00	270.00	45.00	. . .	. . . . .
	Oil meal. . . .	39	225.00	265.00	40.00	. . .	. . . . .
	Clover	44	225.00	275.00	50.00	. . .	. . . . .
		47	185.00	250.00	65.00	. . .	. . . . .
		Av . . .	217.00	265.00	48.00	254	18.9c
Grand total.			4325.00	5250.00	925.00	1031	. . . . .
Average 20 horses			216.25	262.50	46.25	257.7	18c

upon a stationary market is given in Table 16. The table also shows the average increased valuation per horse for the different lots, and the average for all the lots. It will be seen from the above table that the horses of lot 2 increased in valuation from the beginning to the end of the experiment an average of $51.00, which is $3.00 more than the horses of lot 4, $7.00 more than lot 1, and $9.00 more than lot 3, the lot which made the largest gains. The table also shows the increased flesh was worth 18.5c per pound in lot 1, 19.2c in lot 2, 15.4c in lot 3 and 18.9c in lot 4.

Owing to the difficulty of assigning accurate values to horses, it must be understood that it is a very easy matter to rate some horses a little too high and others a little too low. Because of this fact and the small number involved in each lot, it is not safe to attach great weight to the figures giving the value of flesh in the different lots, but the average of all horses in the experiment is a much safer basis from which to make computations. It will then be seen that an average of the twenty horses increased $46.25 each, or at the rate of 18c per pound for each pound of flesh taken on.

It will also be noticed that the horses in lot 1 were appraised $5.00 lower per head at the beginning of the experiment than the horses of lots 3 and 4, and $7.00 lower than the horses of lot 2. The horses of lot 1 were somewhat smaller at the beginning of the experiment than those of the other lots, which in a measure may account for their being rated at a lower value. So far as the efficiency of the rations in producing finish are concerned, there was but little difference in any of the lots. If there was any difference, it was in favor of lots 2, 3 and 4 over that fed lot 1 (corn and clover hay).

ITEMIZED FINANCIAL STATEMENT No. 1

(Profit per horse based on pounds of gain)

LOT 1

Expenditures	
To 1911.6 lb. corn at 43c	$14.68
" 30 lb. oil meal at $27.00	.40
" 2075.2 lb. clover at $13.00	13.49
Total cost of feed	$28.57
Receipts	
By 238 lb. gain at 18c	$42.84
Profit per horse	$14.27
Cost per pound gain	12 cents

LOT 2

Expenditures	
To 1600 lb. corn at 43c	$12.29
" 533.3 lb. oats at 35c	5.83
" 35 lb. oil meal at $27.00	.47
" 2162.3 lb. clover at $13.00	14.05
Total cost of feed	$32.64
Receipts	
By 266 lb. gain at 18c	$47.88
Profit per horse	$15.24
Cost per pound gain	12.3 cents

Lot 3

Expenditures	
To 1077.1 lb. corn at 43c	$ 8.27
" 1077.1 lb. oats at 35c	11.78
" 33.5 lb. oil meal at $27.00	.45
" 2194.1 lb. clover at $13.00	14.26
Total cost of feed	$34.76
Receipts	
By 273 lb. gain at 18c	$49.14
Profit per horse	$14.38
Cost per pound gain	12.7 cents

Lot 4

Expenditures	
To 1807.7 lb. corn at 43c	$13.88
" 351.5 lb. bran at $20.00	3.52
" 34.8 lb. oil meal at $27.00	.47
" 2080.8 lb. clover at $13.00	13.53
Total cost of feed	$31.40
Receipts	
By 254 lb. gain at 18c	$45.72
Profit per horse	$14.32
Cost per pound gain	12.4 cents

The cost of feeding the horses as given in financial statement No. 1, is based upon commercial prices of feeds at the time the experiment was conducted. No charge is made for labor in caring for the horses nor for bedding, neither is any value assigned to the manure made by the horses. It has been assumed that the value of the manure would be enough to offset the cost of the labor involved and the bedding used. From this table it will be seen that lot 2 returned slightly the largest profit, tho there is only 97 cents difference per horse between lot 2 and lot 1, which returned the smallest profit. The cost of feeding lot 3 was $6.19 more per horse than that of lot 1, which is due to the use of oats in the ration of lot 3. While the ration of lot 3 cost more than that of any other lot, it also made larger gains, but the gains were not sufficiently large to justify the high cost of the ration. It will be noticed that the gains of lot 1 cost 12c per lb., while that of lot 2, 12.3c, that of lot 3, 12.7c, and lot 4, 12.4c. Stated in another way and with the above conditions, 85 cents per bushel was realized for the corn fed lot 1; 88 cents for the corn, and 50 cents for the oats fed lot 2; 89 cents for the corn, and 51 cents for the oats fed lot 3, and 88 cents for the corn fed lot 4.

With varying prices of feeds Table 17 gives a summarized statement of the net profit per horse and cost per pound of gain. With moderate priced feeds (corn at 40c, oats at 32c. bran at $20.00 per ton, oil meal at $27.00 per ton and clover hay at $8.00 per ton) it shows that lot 2 would return the greatest profit netting $22.01, which is $1.52 more than that of lot 1. While lot 1 would net the smallest profit it would make gains at a cost of 9.4c per pound, which is cheaper than that of any other lot. As the prices of feeds advance the cost per pound of gain also increases, but even with very high priced feeds the cost per pound of gain would be less and the profits greater with lot 1 than that of any other lot.

TABLE 17. NET PROFIT PER HORSE AND COST PER POUND OF GAIN WITH VARYING PRICES OF FEEDS

Feeds used and at varying prices	With increase gain at 18c per lb.	Lot 1	Lot 2	Lot 3	Lot 4
		Corn Oil meal Clover hay	Corn (¾) Oats (¼) Oil meal Clover hay	Corn (½) Oats (½) Oil meal Clover hay	Corn (4/5) Bran (1/5) Oil meal Clover hay
Corn at 43c, oats at 35c, bran at $20.00 per ton, oil meal at $27.00 per ton, clover hay at $13.00 per ton.	Net profit.	$14.27	$15.24	$14.38	$14.32
	Cost per lb. of gain.	12c	12.3c	12.7c	12.4c
Corn at 40c, oats 32c, bran $20.00 per ton, oil meal $27.00 per ton, clover hay $8.00 per ton	Net profit.	$20.49	$22.01	$21.45	$20.50
	Cost per lb. of gain.	9.4c	9.7c	10.1c	9.9c
Corn at 50c, oats 45c, bran $24.00 per ton. oil meal $30.00 per ton, clover hay $8.00 per ton	Net profit	$17.02	$16.93	$15.10	$16.24
	Cost per lb. of gain.	10.8c	11.6c	12.5c	11.6c
Corn at 60c, oats at 50c, bran at $25.00 per ton, oil meal at $32.00 per ton, clover hay at $10.00 per ton	Net profit.	$11.51	$11.04	$ 9.26	$11.01
	Cost per lb. of gain.	13.2c	13.8c	14.6c	13.7c
Corn at 70c, oats at 60c, bran at $26.00 per ton, oil meal at $34.00 per ton, clover hay at $12.00 per ton.	Net profit.	$ 5.99	$ 4.32	$ 1.75	$ 5.48
	Cost per lb. of gain.	15.5c	16.4c	17.4c	15.8c

Financial statement No. 2 shows what would happen with moderate priced feeds and the flesh produced worth 25c per pound as in Experiment No. 1. From the statement, it will be seen that lot 3 shows the greatest profit per horse by $3.60 more than lot 1, 12 cents more than lot 2, and $2.47 more than lot 4. The cheapest gains would be made in lot 1 at 9.4c per pound, and the most expensive in lot 3 at a cost of 10.1c per pound. The greater profit in lots 2 and 3 is due to the greater gains made being worth 25c per pound, while the cost of production in all the lots is very nearly the same. Where such is the case, the farmer would receive $1.50 per bushel for his corn, and 86c per bushel for his oats, and at the same time help maintain the fertility of his soil by the manure produced.

ITEMIZED FINANCIAL STATEMENT No. 2

(Profit per horse based on pounds of gain)

LOT 1

Expenditures	
To 1911.6 lb. corn at 40c	$13.65
" 30 lb. oil meal at $27.00	.40
" 2075.2 lb. clover hay at $8.00	8.30
Total cost of feed	$22.35
Receipts	
By 238 lb. gain at 25c	$59.50
Profit per horse	$37.15
Cost per pound gain	9.4 cents

LOT 2

Expenditures	
To 1600 lb. corn at 40c	$11.42
" 533.3 lb. oats at 32c	5.33
" 35 lb. oil meal at $27.00	.47
" 2162.3 lb. clover hay at $8.00	8.65
Total cost of feed	$25.87
Receipts	
By 266 lb gain at 25c	$66.50
Profit per horse	$40.63
Cost per pound gain	9.7 cents

LOT 3

Expenditures	
To 1077.1 lb. corn at 40c	$ 7.69
" 1077.10 lb. oats at 32c	10.77
" 33.5 lb. oil meal at $27.00	.45
" 2194.1 lb. clover hay at $8.00	8.78
Total cost of feed	$27.69
Receipts	
By 273 lb. gain at 25c	$68.44
Profit per horse	$40.75
Cost per pound gain	10.1 cents

LOT 4

Expenditures	
To 1807.7 lb. corn at 40c	$12.91
" 351.5 lb. bran at $20.00	3.52
" 34.8 lb. oil meal at $27.00	.47
" 2080.8 lb. clover hay at $8.00	8.32
Total cost of feed	$25.22
Receipts	
By 254 lb. gain at 25c	$63.50
Profit per horse	$38.28
Cost per pound gain	9.9 cents

CONCLUSIONS

1. A mixed grain ration of corn and oats, when fed with clover hay, is more efficient than a single grain ration of corn for producing large gains in an eighty-four day feeding period.

2. While a ration of corn, oats, and clover hay is more expensive with prices of feeds as stated, than one of corn and clover hay, the gains are such as to make its use more economical.

3. Clover hay when fed with a mixed grain ration of corn and oats is more efficient for producing gains than timothy hay. In this test clover hay produced 58 percent more gains than timothy.

4. A ration of corn, oats and timothy is not satisfactory for producing finish in fleshing horses for market, but may be materially improved by the addition of oil meal.

5. Experiment No. 2 showed but little difference in the efficiency of a ration of corn and oats where the oats fed equalled only one-fourth the amount of corn and where the oats and corn were fed in equal quantities by weight, with clover hay as roughage in each ration.

6. A ration of one-fourth oats and three-fourths corn proved more economical than one of half oats and half corn.

7. A ration of corn and bran fed in proportions of one part bran to four parts corn by weight is superior to an all-corn ration for producing gains when fed in conjunction with clover hay.

8. This test seemed to indicate that there is danger of feeding too much bran for best results when clover hay furnishes the roughage part of the ration. The bran and clover combined produced a too laxative condition.

9. A ration with a nutritive ratio of 1 : 10 is too wide for best results in fleshing horses. In these tests the narrower the nutritive ratio the larger the gains. Best results were secured with a nutritive ratio of 1 : 8.

10. Exercise has a retarding effect upon the taking on of flesh. In this test the horses receiving no exercise made 24 percent more gains than those having a daily walk of 2.8 miles.

11. While box stalls are safer than single stalls for stabling horses, they are also more expensive and do not offer merits not possessed by single stalls so far as they may influence the horse in taking on flesh. The horses stabled in single stalls made 16 pounds or 8 percent more gains in 84 days than those in box stalls.

12. Thin horses of some market classes will not return as large a profit in feeding as those of other classes. The kind of horses it will pay best to feed depends partially upon the season of the year when marketed. All heavy horses will pay better than light horses, and good and choice animals better than those of the lower grades.

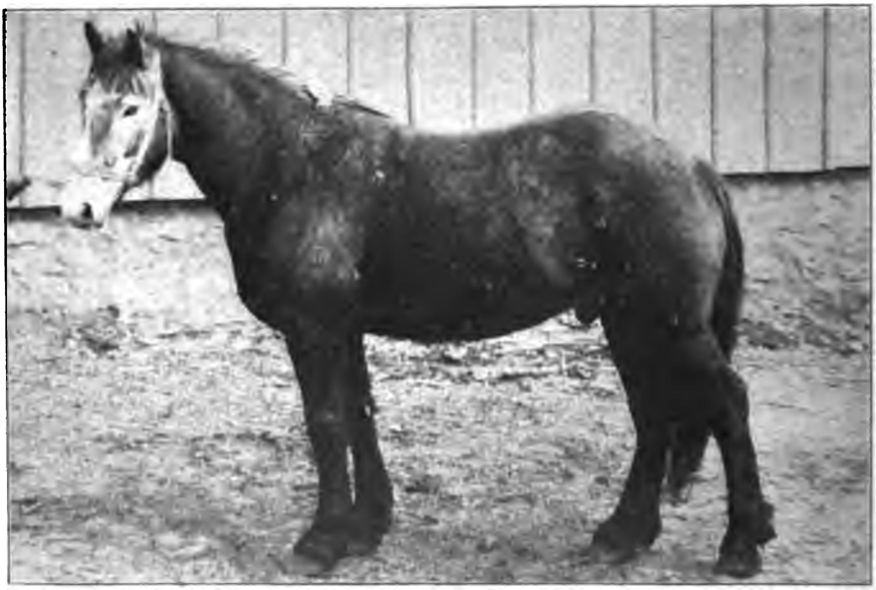

PLATE 1. No. 6. BEFORE FEEDING. EXPERIMENT 1, LOT 1.

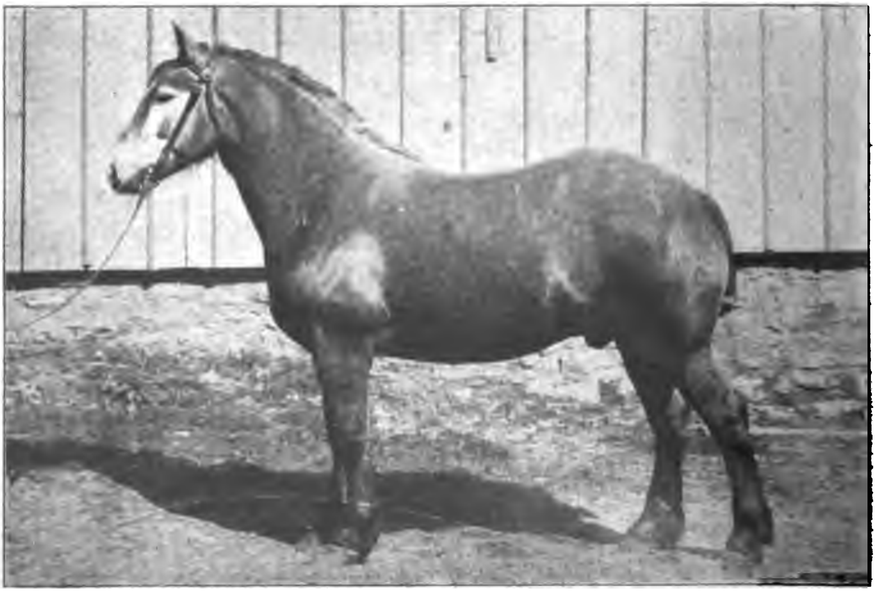

PLATE 2. No. 6. AFTER FEEDING. EXPERIMENT 1, LOT 1.

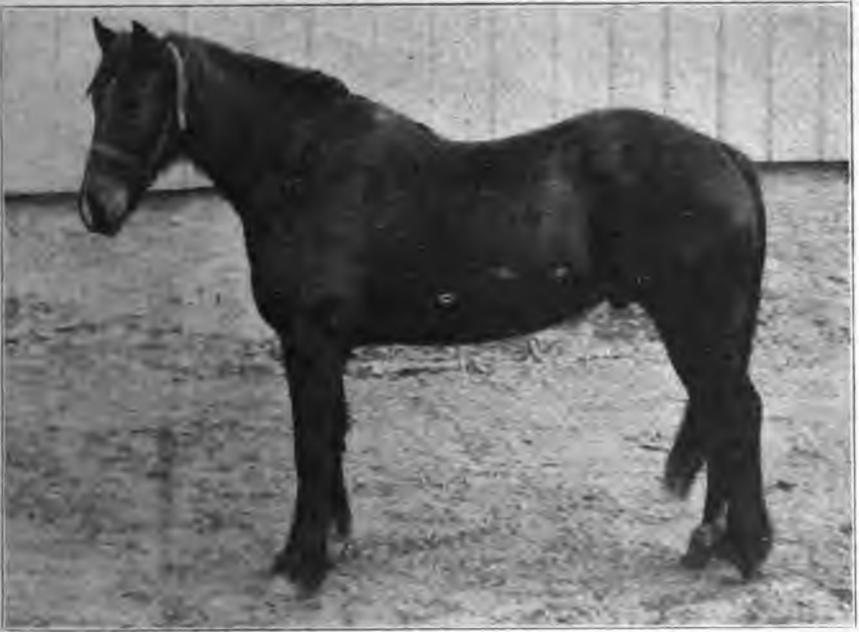

PLATE 3. NO. 11. BEFORE FEEDING. EXPERIMENT 1, LOT 2.

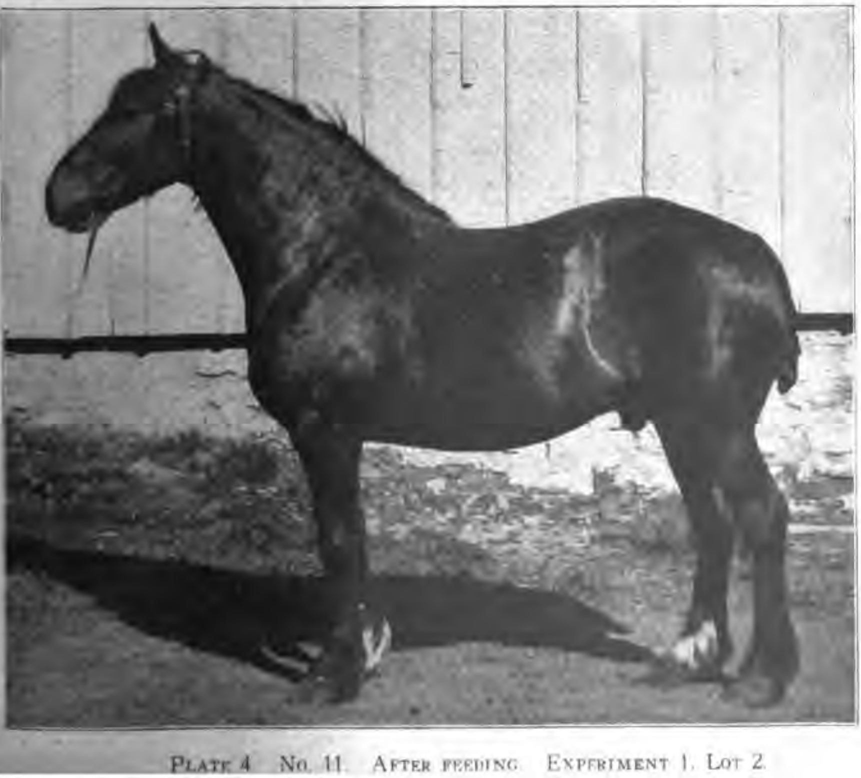

PLATE 4. NO. 11. AFTER FEEDING. EXPERIMENT 1, LOT 2.

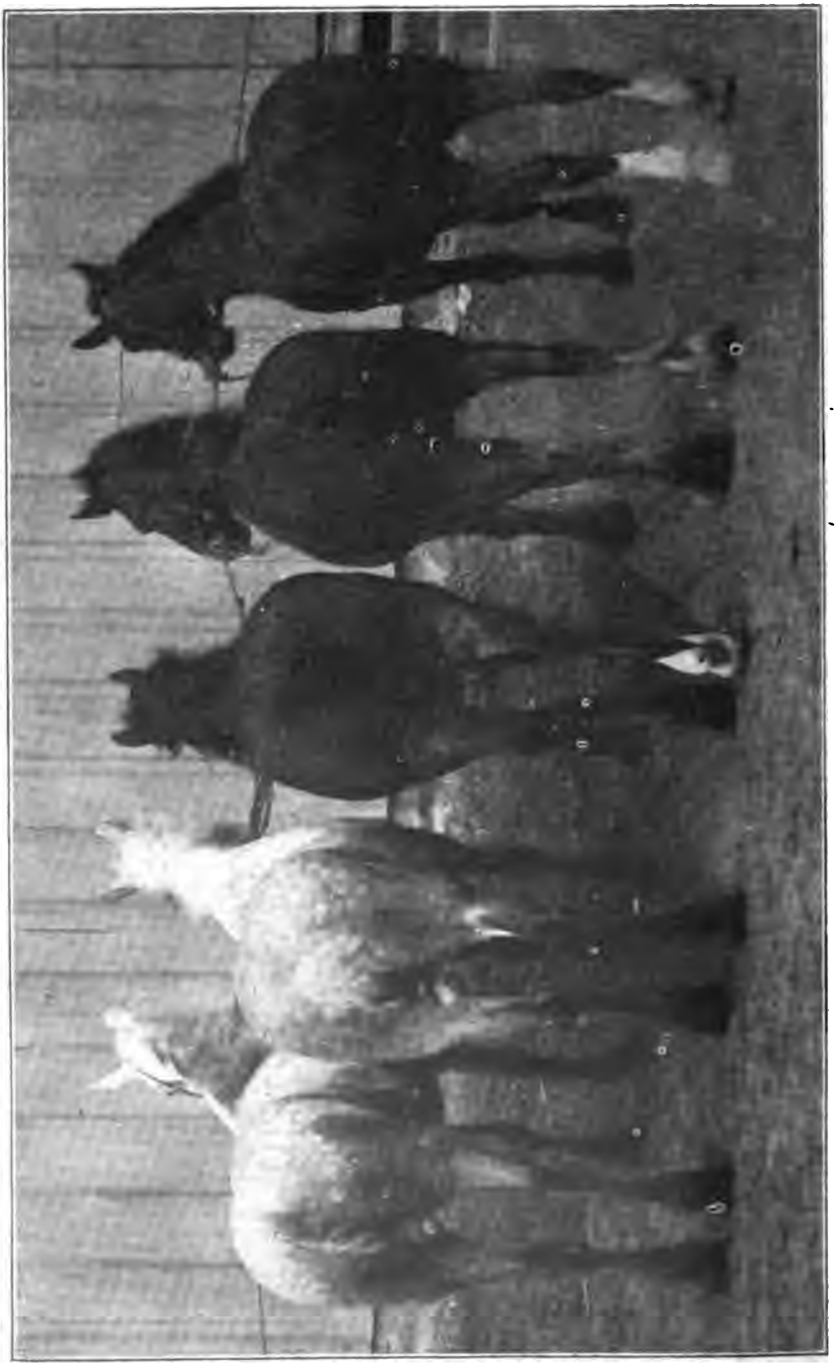

PLATE 7. EXPERIMENT 1, LOT 3. AVERAGE WEIGHT 1477 POUNDS.

NOTE.—The center horse was rejected from the experiment.

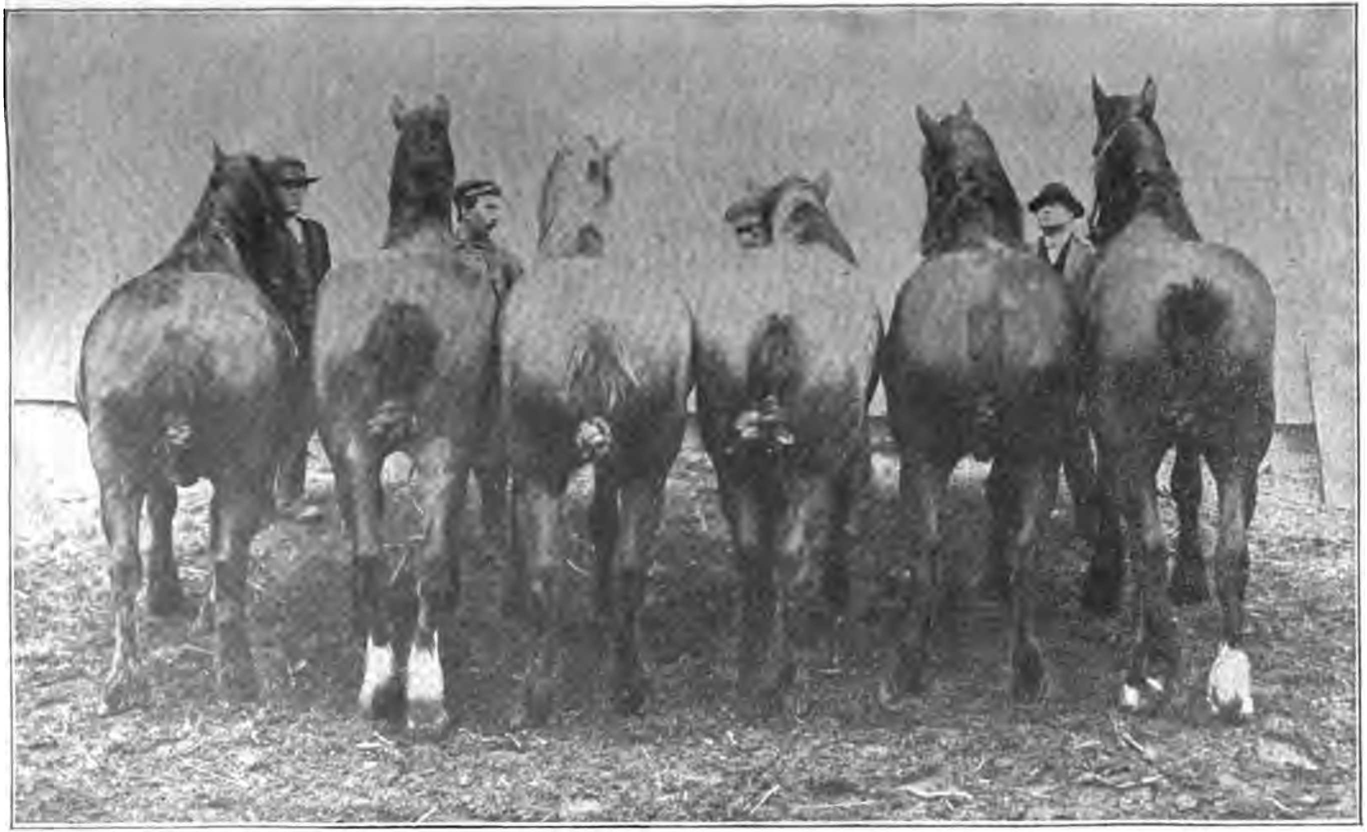

PLATE 8. EXPERIMENT 2, LOT 1. AVERAGE WEIGHT 1674 POUNDS.

NOTE.—The second horse from the left was rejected from the experiment.

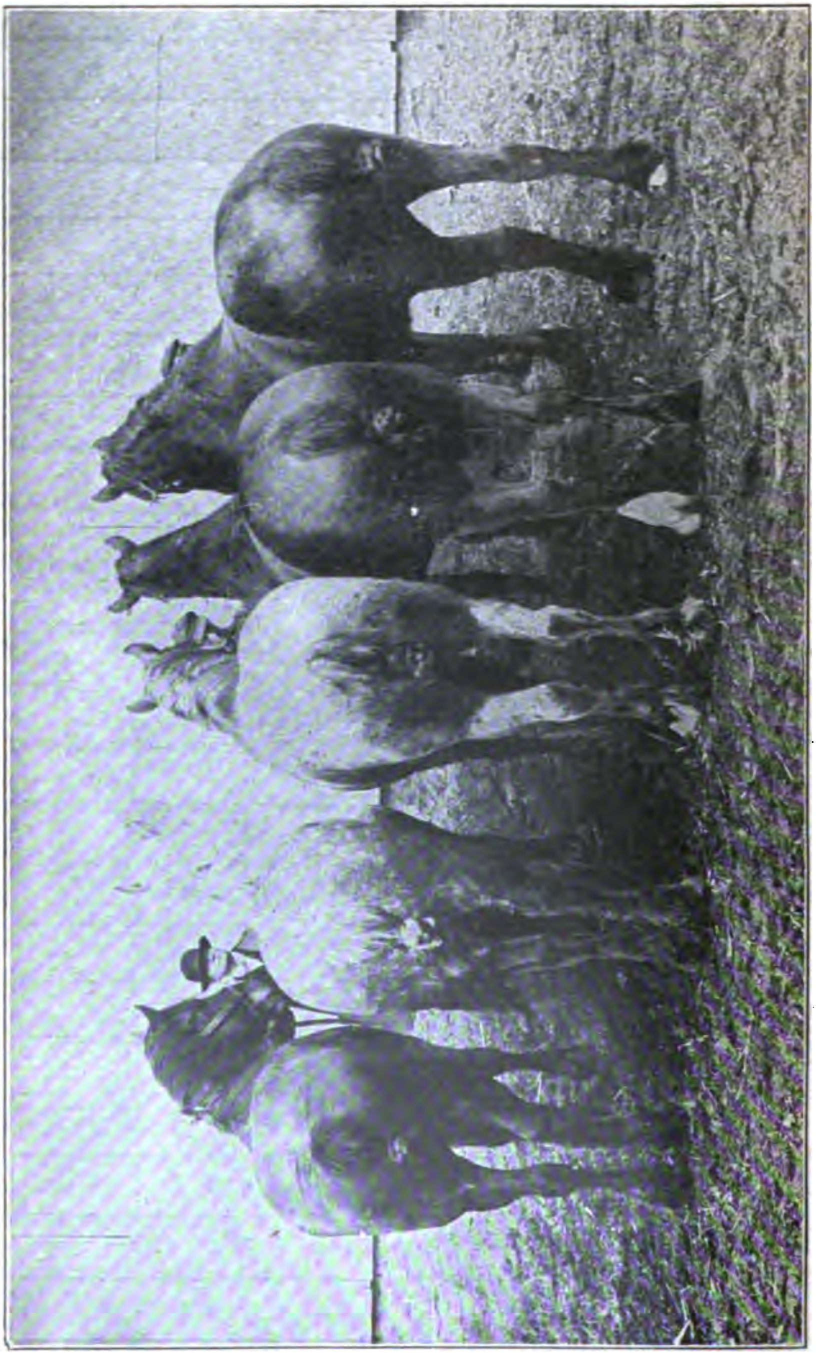

PLATE 9. EXPERIMENT 2, LOT 2. AVERAGE WEIGHT 1734 POUNDS.

PLATE 8. EXPERIMENT 2, LOT 1. AVERAGE WEIGHT 1674 POUNDS.

NOTE.—The second horse from the left was rejected from the experiment.

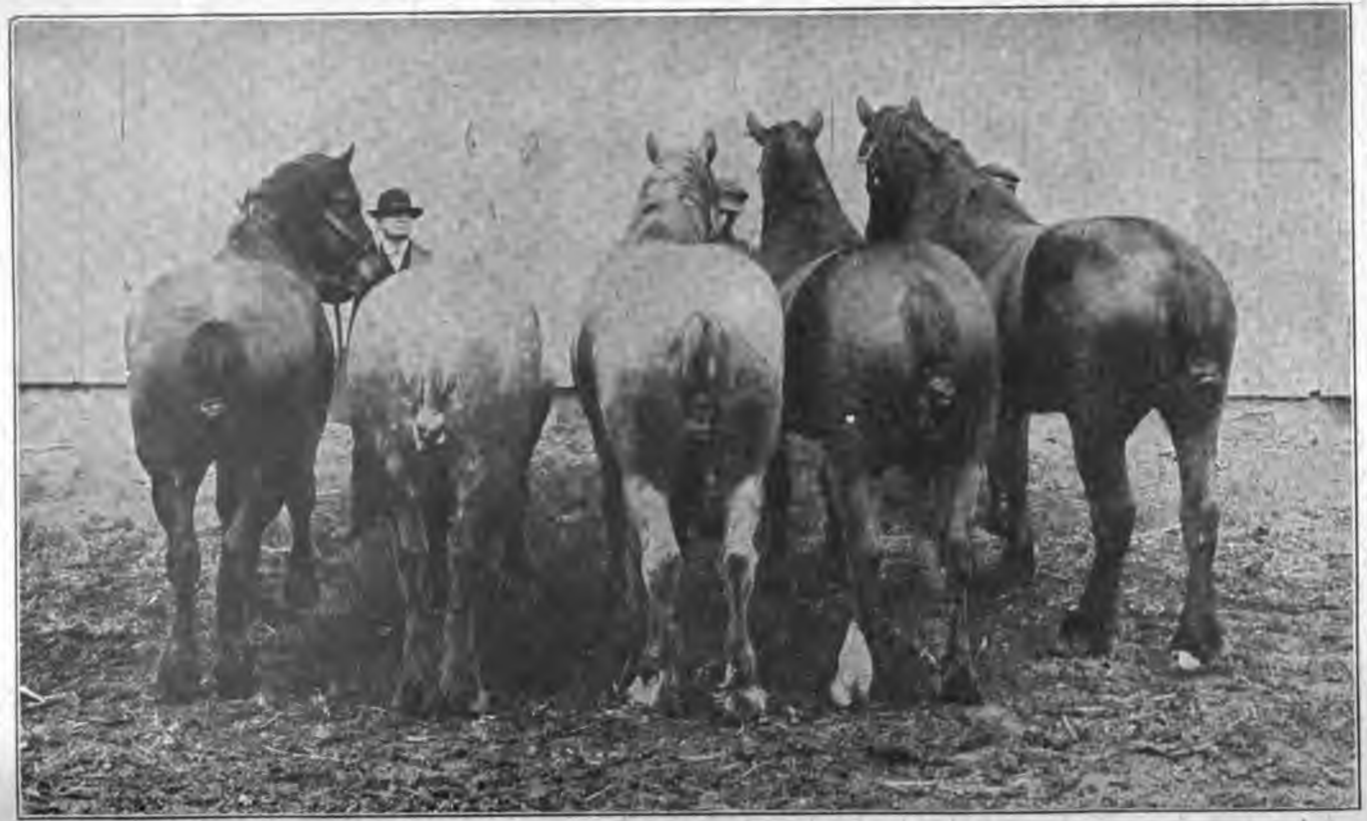

PLATE 9. EXPERIMENT 2, LOT 2. AVERAGE WEIGHT 1734 POUNDS.

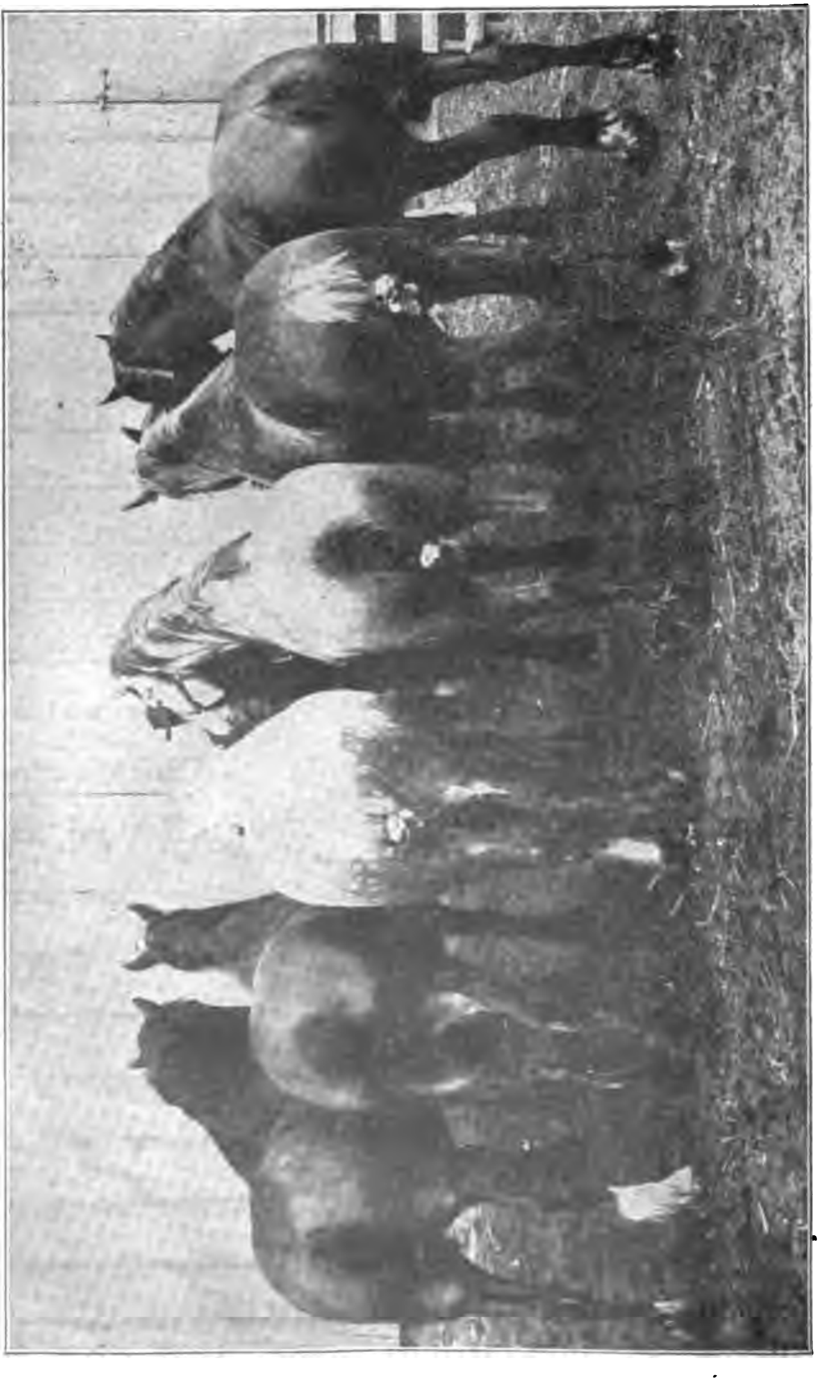

PLATE 11. EXPERIMENT 2, LOT 4. AVERAGE WEIGHT 1755 POUNDS.

NOTE.—The third horse from the right was rejected from the experiment.

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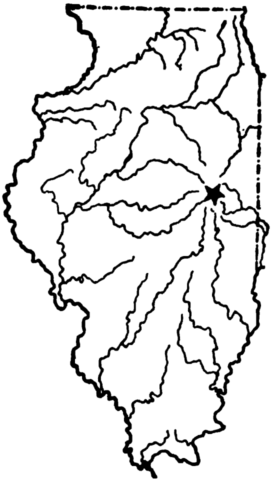
BULLETIN No. 142

SHORT FED STEERS
A COMPARISON OF METHODS OF FEEDING

By HERBERT W. MUMFORD and H. O. ALLISON



URBANA, ILLINOIS, NOVEMBER, 1909

SUMMARY OF BULLETIN NO. 142

1. Under the conditions of the experiment, the profit to be derived from short feeding cattle was 7.36 percent interest on the total expenditure for ninety days for lot 1 and 18.88 percent for lot 2.

2. With expenses as figured the necessary margin per cwt. between buying and selling price in Chicago in order to break even was $1.137 for lot 1 (common method of feeding) and $1.166 for lot 2 (chopped hay and self-feeder), when the pork produced is not considered.

3. Mixed feed when fed thru a self-feeder is especially advantageous for accustoming cattle to a heavy grain ration in a short time.

4. By the use of mixed feed and the self-feeder the necessity of a skillful feeder is reduced.

5. Cattle fed chopped hay mingled with concentrates thru a self-feeder will consume larger quantities of feed than when the same feeds are fed separately at regular periods twice per day.

6. By chopping the hay, mingling it with the grain and feeding thru a self-feeder as in lot 2, more rapid gains were secured and at slightly less cost per pound than when these same feeds were fed separately twice per day as in lot 1.

7. The larger gain of lot 2 resulted in better finish, 15 cents per cwt. higher selling price, and $2.05 per steer more profit (not including pigs) than lot 1.

SHORT FED STEERS
A COMPARISON OF METHODS OF FEEDING

By HERBERT W. MUMFORD, Chief in Animal Husbandry, and
H. O. ALLISON, Assistant in Animal Husbandry

INTRODUCTION

Among common methods of beef production there is recognized the practice of short feeding or "warming up" of cattle. This process usually requires from 60 to 100 days and the cattle are generally marketed in a half fat or unfinished condition. In this, as in most enterprises of this sort, the variations of common practice are wide. These variations are in the grade and condition of cattle selected for feeding, the methods of handling, and the rations used. Some feeders, for instance, select heavy fleshy cattle of the better grades while others select cattle thin in flesh, but generally mature, and of the lower grades. Then too, the variations in the methods of handling the cattle are wide, the chief difference being in the policy of forcing rapid and large gains by the use of a rather expensive ration as compared with that of smaller gains by the use of limited quantities of feed or less expensive feeds.

The factors surrounding and the possibilities of short feeding are considerably different from those of long feeding where the cattle are fed for six months or longer and generally marketed in finished condition. It is not intended, however, at this time to compare the practice of short feeding with that of finishing beef cattle. We introduced this work rather to study the methods and possibilities of short feeding. To do this, a test was conducted with two carloads of cattle under conditions comparable to those existing in Illinois. In this work the relative merits of two different methods of feeding were studied and other available data were collected thus supplying a basis upon which the business of short feeding cattle may be judged.

Conditions of the Experiment

The steers used in the experiment were purchased on the Chicago market August 22, 1905. They consisted of thirty-four head of good to choice, fleshy, three-year-old feeders. All were dehorned and the average weight was 1,073 pounds in Chicago. They were natives and northwest rangers mixed, but all were undoubtedly strictly grass cattle. Upon arrival at the experimental farm, they were divided into two lots of seventeen head each. In this division every effort was made to make the lots as nearly alike as possible in quality, condition and weight. In order to make the test as practical and simple as possible, the usual preliminary feeding period was dispensed with and the steers were put on experiment two days after their arrival.

To secure the corrrect weight of the steers at the beginning of the experiment, they were weighed on three consecutive mornings, August 24, 25, and 26, before feeding and watering. The average of these weights was then taken as the correct weight at the beginning of the test which began on August 25. The experiment was divided into periods of two weeks, the cattle being weighed at the end of each period under the same conditions as to water and feed.

Both lots received the same feeds consisting of corn meal, oil meal, and clover hay. Lot 1 received these according to the common method of feeding, that is, whole hay and concentrates fed separately at regular feeding periods twice per day. In the case of lot 2 the clover hay was chaffed by running it thru an ordinary ensilage machine and it was then mingled with the grain portion of the ration and fed thru a self-feeder, to which the cattle had access at all times.

Four pigs were placed in each lot to utilize whatever undigested feed passed thru the steers. While it was thought at the time that more pigs might have been used to advantage, the difficulty in securing them made the trial impossible.

FEED LOTS AND EQUIPMENT

With the exception of the method of feeding, the conditions surrounding both lots were alike. Owing to the prevailing warm weather at the begining of the experiment, it was thought best not to confine the steers to a small feed lot with no shade other than that provided by the shed. Consequently they were given the run of small paddocks 237 x 112 feet which adjoined the feed lots. Along one end of these extended a double row of soft maple trees which furnished ample shade and under which the cattle spent most of their time during the day. These paddocks were sodded with blue-grass, but as it had been pastured during the forepart of the season there was no available feed when the cattle were turned in, and because of the tramping and soiling from the droppings, the steers obtained no feed from this source. It may be said, however, that the pigs ate some of the grass and likely profited slightly thereby.

The feed lots proper were paved with brick and measured 36 x 48 feet, with a 12 foot shed running along the north side. In these small lots the cattle were fed and allowed to run at all times. The steers had access to pure, fresh water supplied in galvanized steel tanks into which it was drawn from the University plant. The concentrates were supplied to lot 1 in an open feed-box similar to that used in the ordinary feed lot, while the clover hay was fed in mangers along the side of the lot. As the hay and grain were mixed for lot 2, a specially adapted self-feeder was constructed thru which the mixture would run as the cattle needed it.

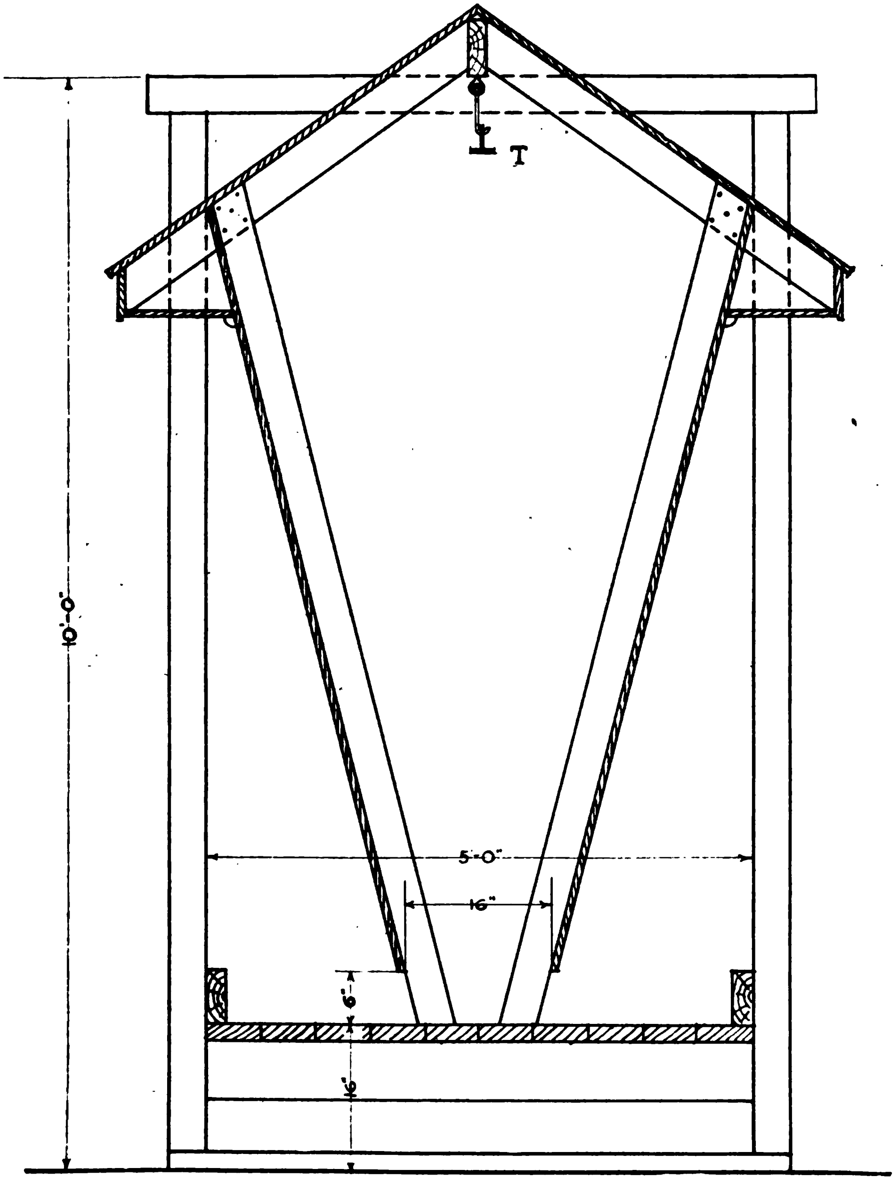


PLATE 1. SECTIONAL VIEW OF SELF-FEEDER.

Plate 1 shows a cross section of the self-feeder giving the essential features of its construction. It was so arranged that the feed could be conveyed by means of a feed carrier on a suspended track from the barn to the feeder into which the feed was dumped. The track was similar to those used for hay carriers and is shown at point T. The rectangular frame which was 5 feet wide and 10 feet high was constructed of 4 x 4-inch material. This served as a frame for the feeder as well as a support for the track. It will be noticed from the cut that the bin was but 16 inches wide at the opening and this opening was 6 inches high. This construction seemed necessary in order to enable the cattle to work the feed out as needed and to prevent clogging. The studding, which were 2 x 4-inch material, were placed four feet apart inside the bin and served as supports to the sides. Other than these points the feeder was not essentially different from those commonly in use in the corn belt.

QUALITY AND COST OF FEEDS

The feeds used were corn meal, oil meal, and clover hay. The corn graded No. 2 yellow, and the clover hay No. 1. The oil meal was "Old Process," ground linseed cake, pea size. The cost of these feeds and their preparation was as follows:

	Per ton
Cost of grinding corn, $0.060 per cwt. or	$ 1.200
Chopping hay by running thru ensilage machine, $0.05 per cwt. or	1.000
Shelled corn, $0.35 per bu. or	12.499
Ground corn, including cost of grinding	13.699
Clover hay	8.000
Chopped clover hay	9.000
Oil meal (ground linseed cake, pea size)	28.000

METHOD OF FEEDING STEERS

Owing to the shortness of the feeding period it was thought best to get the cattle on full grain feed as soon as possible in order to secure the greatest gain in live weight and best finish, as this principle was thought to be desirable in short feeding. Oil meal was used to supplement the ground corn because it has been found at the Illinois Station that it contributes to the production of larger gains by stimulating the appetite so that larger quantities of concentrates are consumed to advantage.* The full grain feed was reached by gradually increasing the grain ration in lot 1 and the proportion of concentrates to roughage in lot 2, the rate of change varying somewhat with the appetite of the cattle. At the end of four weeks they were practically on full feed with no bad effects noticeable except with one steer in lot 1. He appeared to have a slight attack of indigestion and did not eat well from September 16 to 22.

Table 1 shows the average daily ration per steer by periods. These periods correspond with the periodical weights which were taken every two weeks. Period 1 extended from August 25 to September 8;

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*Illinois Bulletin No. 103 Page 80.

Period 2, September 8 to 22; Period 3, September 22 to October 6; Period 4, October 6 to 20; Period 5, October 20 to November 3; Period 6, included 19 days from November 3 to 21.

TABLE 1. AVERAGE DAILY RATION PER STEER BY PERIODS (POUNDS)

		Periods						Average 89 days, Aug. 25 to Nov. 21
Lot	Feeds	1	2	3	4	5	6	
1	Ground corn...	9.45	18.69	17.92	20.91	23.19	22.81	19.05
	Oil meal.......	1.81	2.98	2.71	3.23	3.23	3.41	2.92
	Clover hay....	18.47	14.60	15.05	13.39	11.53	9.13	13.45
2	Ground corn...	10.78	21.59	22.01	27.26	25.20	22.06	21.52
	Oil meal.......	2.06	3.27	2.52	3.82	3.79	3.31	3.13
	Chopped clover	16.63	17.85	12.60	12.18	10.50	8.39	12.77

It will be seen from Table 1 that lot 2 cosumed the most feed. This was also noticeable from the appearance of the cattle during the experiment as lot 2 carried the best fill. We can attribute this to no other cause than the method of feeding, as lot 1 could not be induced to take more feed.

The decreased consumption in Period 3 in the case of lot 1 was due to a change in ground corn which it was impossible to avoid. While the meal seemed sweet and good in every way, it was ground by the burr process while the plate grinder had previously been used. As a result it took the cattle in lot 1 several days to become accustomed to it, whereas with lot 2, the corn being mingled with the hay, the falling off was not so noticeable.

TABLE 2. PROPORTION OF CONCENTRATES TO ROUGHAGE

	Periods						Average 89 days
	1	2	3	4	5	6	
Lot 1	1:1.64	1:0.67	1:0.72	1:0.55	1:0.43	1:0.34	1:0.61
Lot 2	1:1.29	1:0.71	1:0.51	1:0.39	1:0.36	1:0.33	1:0.51

The above table shows the proportion of concentrates to roughage for both lots during different periods. The plan was to cater to the appetites of the cattle in these proportions and as a result lot 1 took a larger proportion of hay than lot 2. When we consider that the cost of digestible nutrients in the case of lot 1 is .9029 cents per pound in form of hay and .8692 cents per pound in form of corn (which is .0337 cents per pound greater in the form of hay than in corn),* it is probable that this larger proportion of roughage would work as a handicap to lot 1 in the cost of producing gain. It will be noticed that from the first period on, the proportion of grain was gradually increased until at the close of the experiment the grain ration was about three times that of the roughage.

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*Average Composition of American Feeding Stuff—Henry's Feeds and Feeding.

TABLE 3. AVERAGE DAILY GAIN PER STEER IN POUNDS BY PERIODS AND AVERAGE FOR WHOLE TIME

Lot No.	1	2	3	4	5	6	Average 89 days
1	4.117	1.910	3.025	2.976	3.466	2.554	2.984
2	4.147	2.794	3.088	3.655	4.242	2.337	3.326

TABLE 4. SUMMARY OF TABLE 3 (POUNDS)

	Periods			
Lot No.	Aug. 25 to Sept. 22	Sept. 22 to Oct. 20	Oct. 20 to Nov. 21	Aug. 25 to Nov. 21
1	3.014	3.000	2.941	2.984
2	3.470	3.371	3.146	3.326

Table 3, shows the average daily gain per steer during the periods corresponding to those in Table 1. Owing to the great variation in the weights of steers it has seemed best to summarize these six periods into three in order to study the relative rate and cost of gains. Consequently periods 1 and 2, 3 and 4, and 5 and 6 are summarized in Table 4. From this it can be readily seen that lot 2 made the larger gains, but the difference in rate of gain decreases as the feeding period advances. This indicates that the mixed feed fed thru a self-feeder may be especially advantageous for accustoming cattle to a grain ration. It also indicates that the difference in its favor would probably be more marked in the short than in the long feeding period.

TABLE 5. AVERAGE COST PER POUND OF GAIN BY PERIODS AND AVERAGE FOR THE ENTIRE EXPERIMENT

(Value of pork produced not credited to steers)

	Aug. 25 to Sept. 22	Sept. 22 to Oct. 20	Oct. 20 to Nov. 21	Aug. 25 to Nov 21 89 days
Lot 1	$0.0650	$0.0770	$0.0832	$0.0753
Lot 2	0.0650	0.0797	0.0798	0.0749
(Value of pork produced credited to steers)				
Lot 1	0.0637	0.0753	0.0817	0.0739
Lot 2	0.0638	0.0747	0.0763	0.0711

Table 5 summarizes the cost of gains. While the data presented here are probably not sufficient to warrant a definite conclusion, it indicates that the diminishing efficiency of the feed consumed as the feeding advances was slightly more marked in lot 1 than in lot 2. In the lower part of the table the value of the pork produced was deducted from the expense, thus reducing the cost per pound gain of beef. Another point of significance as shown by Table 5, is the similarity in the average cost of gain for the two lots for the entire period.

Large consumption of feed in order to produce maximum gains is generally associated with expensive gains. In this case, however, the self-fed cattle (lot 2) produced an average daily gain per steer of .342 pounds more, and not figuring value of pork produced, the cost was four hundredths of a cent per pound less than the hand fed lot, (lot 1). It should also be kept in mind that the cost of the chopped hay was one dollar per ton more than the ordinary hay and this extra charge was figured in the cost of gain. This indicates strongly then, that for short feeding cattle, there is an advantage in chopping the hay, mingling it with the grain and feeding thru a self-feeder.

TABLE 6. WEIGHT OF STEERS AND EXTENT OF GAINS IN POUNDS

	Total Wt. 17 steers		Average Wt. per steer		Average gain in 89 days	
Lot No.	Beginning of Exp.	Close of Exp.	Beginning of Exp.	Close of Exp.	Total per steer	Per steer per day
1	18,110	22,625	1065.29	1330.88	265.58	2.98
2	18,176	23,200	1069.17	1364.70	295.52	3.32

Table 6 shows the total and average weights of the steers at the beginning and close of the experiment and the total and average daily gain per steer. As the increase in live weight of mature cattle is largely fat, we might suppose that the steers in lot 2, which had gained 29.94 pounds per steer more, would be fatter and consequently worth more on the market. This was corroborated by the values placed on the steers in Chicago at the close of the experiment.

MARKETING

In preparing the cattle for shipment three feeds of timothy hay were substituted at the last for the clover hay usually fed. Two of these were included in the feed before the final weights were taken. No special account is made, however, in the feed tables of this hay, as it was thought to be of too little difference in value and importance to be considered as affecting the gains or the cost to any noticeable extent. The last feed lot weight was taken on the morning of November 22, before the cattle had been fed or watered. They were then fed timothy hay and about half the usual grain feed. They also had access to water for an hour, after which it was removed.

In the afternoon, between three and four o'clock, the cattle were quietly driven a distance of about a mile to the loading chutes, where they were loaded at about five o'clock. They arrived and were unloaded in Chicago the following morning at 6:30 Thursday, November 23. After being allowed to fill, their value was estimated by expert judges. Lot 1 was estimated at $5.45 and lot 2 at $5.60 per cwt. on the then existing market. This makes a margin between buying and selling price of $1.20 per cwt. in the case of lot 1, and $1.35 per cwt. for lot 2. For commercial reasons the two loads were turned together and sold as one bunch for $5.60 per cwt. The Chicago weight was taken at 9 a. m. November 23 and showed a shrinkage for the entire thirty-four head of 1,175 pounds, an average of 34.558 pounds per steer.

As the cattle were sold together the dressing percentages obtained were for the entire 34 head. They are as follows, 58.10 percent beef; 6.80 percent fat, and 6.65 percent hides. There is little to be said concerning these figures. In general, however, the cattle were "Good" to "Choice" in grade at the time of marketing.

ITEMIZED STATEMENT OF COST OF FEEDERS

To 34 steers, 36,490 lb. @ $4.25 per cwt.	$1,550.82
Commission	20.00
Freight, two cars	41.88
Feed prior to experiment	4.00
Total expense	$1,616.70

The above statement shows the expense to be $1,616.70, and since the cattle only weighed 36,286 pounds at the beginning of the experiment, having shrunk 204 pounds, or 6 pounds per head, their actual cost was $4.455 per cwt. at the feed lot.

ITEMIZED FINANCIAL STATEMENT

Lot 1, 17 steers

To 17 steers, 18,110 lb. @ $4.455 per cwt.	$806.800
14.416 tons ground corn @ $13.699 per ton	197.488
2.214 tons oil meal @ $28.00 per ton	61.999
10.175 tons clover hay @ $8.00 per ton	81.404
Freight Champaign to Chicago, commission, feed and yardage	38.440
Total expenditures	$1,186.131
By 17 steers 22,037.5 lb. @ $5.45 per cwt.	$1,201.043
140 lb. pork @ $5.00 per cwt.	7.000
Total receipts	$1,208.043
Total expenditures	$1,186.131
Total profit	$ 21.912
Profit per steer	1.288

ITEMIZED FINANCIAL STATEMENT

Lot 2, 17 steers

To 17 steers, 18,176 lb. @ $4.455 per cwt.	$ 809.740
16.282 tons ground corn @ $13.699 per ton	223.050
2.375 tons oil meal @ $28.00 per ton	66.500
9.661 tons chopped clover @ $9.00 per ton	86.950
Freight Champaign to Chicago, commission, feed and yardage	38.440
Total expenditures	$1,224.680
By 17 steers 22,612.5 lb. @ $5.60 per cwt.	$1,266.300
325 lb. pork @ $5.00 per cwt.	16.250
Total receipts	$1,282.550
Total expenditures	$1,224.680
Total profit	$ 57.870
Profit per steer	3.404

The itemized financial statement shows that no charge was made for the labor involved in feeding the steers after the feed was prepared. The general custom is to allow the value of the manure produced to balance the cost of the labor involved. There seemed to be but little difference in the amount of labor necessary to feed the two lots, altho it was of a little different nature. For lot 1 the skill of the feeder was an important factor and called for regularity in the work. On the other hand for lot 2 the work was not necessarily regular, but involved considerable labor in mingling the concentrates with the chopped hay.

The larger amount of pork produced in lot 2 accounts for part of the difference in profit. The reason the pigs did better in this lot was partly due to the steers throwing small quantities of feed out of the self-feeder. Being from this source it seems proper to credit the account with this full amount of pork produced.

In general, the financial results of this experiment are favorable to the method of feeding used for lot 2. While the data given in this publication are not extensive, they indicate that for short feeding cattle the plan of chaffing hay, mingling it with grain, and feeding thru a self-feeder is worthy of further investigation and trial by feeders.

TABLE 7. EFFECT OF VARIOUS PRICES OF CORN ON PROFIT OR LOSS

Lot 1

Cost per bushel, cents	35	40	45	50
Profit total.............	+$21.912	—$ 3.831	—$29.574	—$55.317
Profit per steer.........	+ 1.288	— 0.225	— 1.739	— 3.253

Lot 2

Cost per bushel, cents	35	40	45	50
Profit total.............	+$57.870	+$28.795	—$ 0.280	—$29.355
Profit per steer.........	+ 3.404	+ 1.693	— 0.016	— 1.726

The matter of profit or loss in feeding operations naturally depends upon the cost of the feed as compared with the price of beef. For this reason the above will be of interest as it gives the effect of various prices of corn on the financial statement. In the above table the plus or minus signs refer to profit or loss. Five cents per bushel difference in the price of corn changes the total expense of lot 1, $25.743; of lot 2, $29.075; or an equivalent in the final cost of the market weight of the cattle of 11.6 cents per cwt. in case of lot 1, and 12.8 cents with lot 2.

TABLE 8. PROFIT OR LOSS AS INFLUENCED BY THE MARKET

	Falling		Stationary		Rising	
	Total	Per steer	Total	Per steer	Total	Per steer
Lot 1	—$33.181	—$1.951	+$21.912	+$1.288	+$77.005	+$4.529
Lot 2	+ 1.331	+ 0.078	+ 57.862	+ 3.403	+114.393	+ 6.729

The cattle were bought and sold on practically a uniform or stationary market. That is, they would have sold at the time they were purchased for about the same price that they did at the close of the experiment had they been in the same condition. These conditions do not always exist, however, so in order to see the effect of a fall or rise of 25 cents per cwt. in the market Table 8 is presented. Under the falling market the selling price for lot 1 is figured at $5.20, stationary $5.45, and rising at $5.70 per cwt., making a difference in total receipts in each case of $55.094. For lot 2 the falling market was figured at $5.35, stationary $5.60 and rising at $5.85 per cwt., making a difference in total receipts in each case of $56.531. The minus signs in the table indicate a loss while the plus signs indicate a profit.

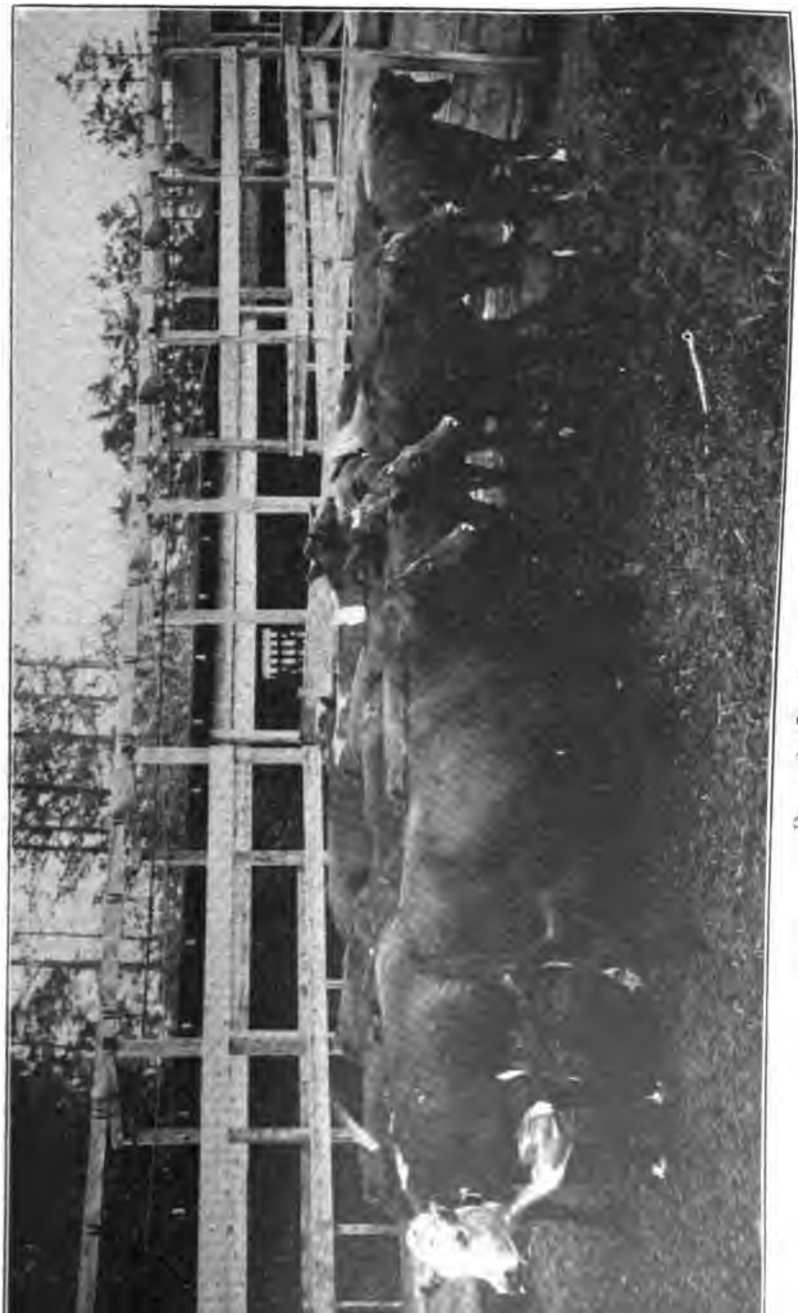

PLATE 2. LOT 1, AS FEEDERS.

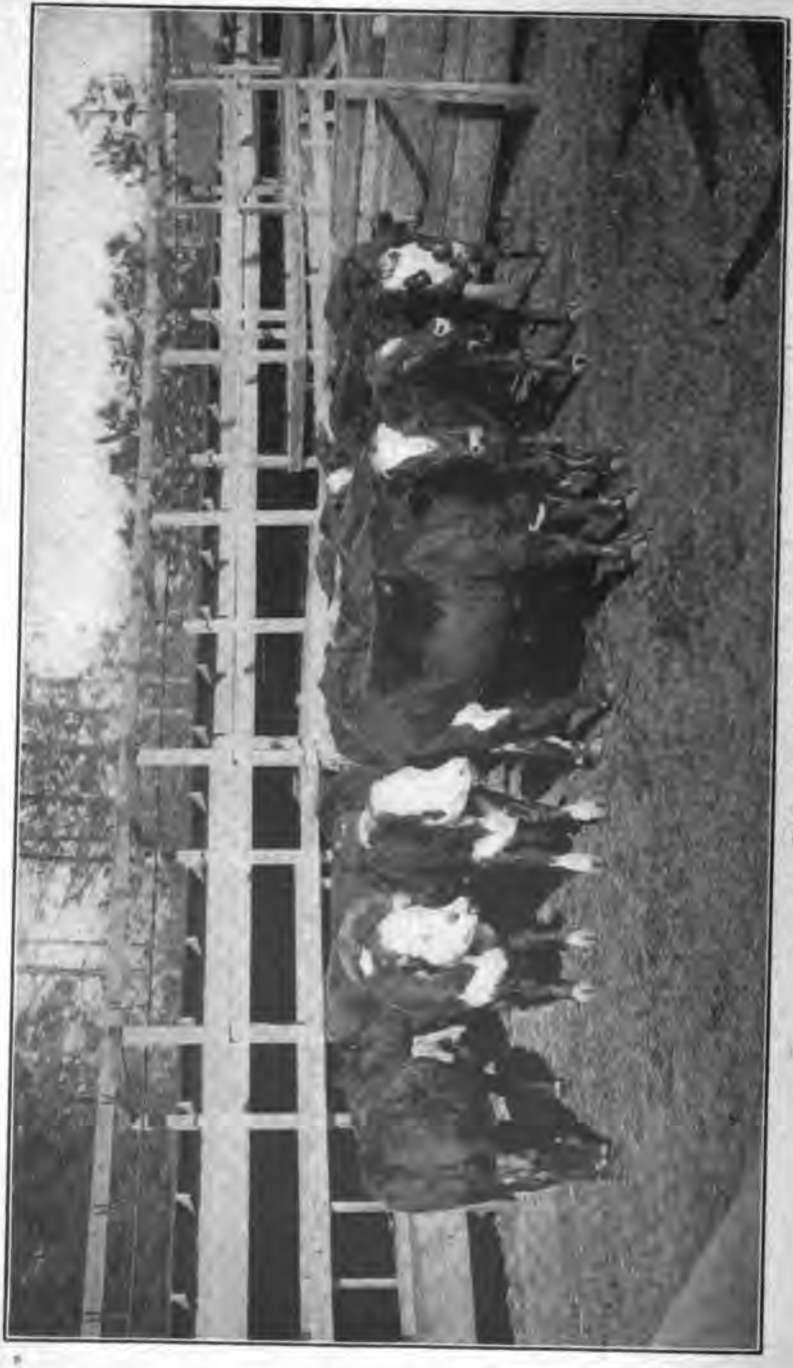

PLATE 3. LOT 1, AS MARKETED.

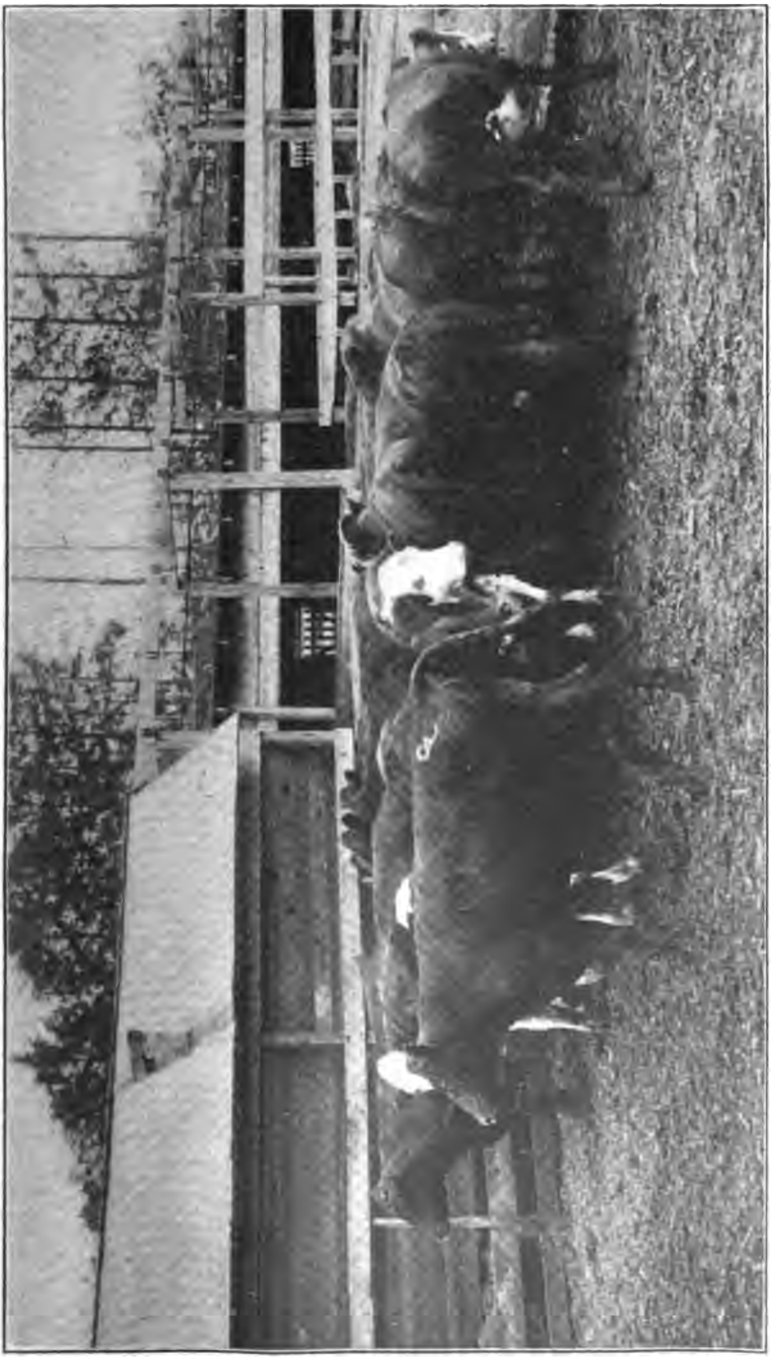

PLATE 4. LOT 2, AS FEEDERS.

PLATE 5. LOT 2, AS MARKETED.

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BULLETIN NO. 143

ECONOMY OF THE ROUND DAIRY BARN

BY WILBER J. FRASER

URBANA, ILLINOIS, FEBRUARY, 1910

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SUMMARY OF BULLETIN No. 143

1. Round barns would be more generally built if their advantages were known and if the few which have been erected had been rightly constructed. Page 1.

2. The round dairy barn offers greater convenience in storing, handling and distributing the feed. Page 5.

3. In the circular construction, much greater strength is secured with less lumber. Page 6.

4. The material for rectangular barns costs from 34 to 58 percent more than for round barns of the same area and capacity. Page 7.

5. Round and rectangular barns compared. Page 11.

6. Round and rectangular barns, including silos, compared. Page 13.

7. Detailed account, with illustrations showing how the round barn at the University was built. Page 17.

8. Itemized statement of cost of a 60-foot round barn. Page 29.

9. Brief descriptions with illustrations and plans of several round dairy barns in actual use. Page 31.

10. Conclusions. The advantages of the round dairy barn are convenience, strength and cheapness. Page 44.

ECONOMY OF THE ROUND DAIRY BARN

FULL SPECIFICATIONS AND DETAILED COST AND CONSTRUCTION OF THE NEW SIXTY-FOOT CIRCULAR DAIRY BARN AT THE UNIVERSITY. SAVING OF ROUND OVER RECTANGULAR BARNS. NOTES ON SEVERAL ROUND BARNS ON DAIRY FARMS.*

BY W. J. FRASER, CHIEF IN DAIRY HUSBANDRY

The planning, construction, and arrangement of farm buildings do not usually receive the thought and study these subjects warrant. How many dairymen have compared a circular, 40-cow barn with the common rectangular building containing the same area? How many understand that the circular structure is much the stronger; that the rectangular form requires 22 percent more wall and foundation to enclose the same space; and that the cost of material is from 34 to 58 percent more for the rectangular building?

In a community in which everyone is engaged in the same occupation, one person is likely to copy from his neighbor without apparently giving a thought as to whether or not there is a better way.

In a district of Kane county, Illinois, a certain type of dairy barn is used by nearly everyone, while in the next county a distinctly different type prevails, and the dairy barns of another adjacent county differ from those of either of the former, simply because the early settlers of this particular locality came from an eastern state and started building the style of barn then common in Pennsylvania.

In a certain community in Ohio where a milk condensing factory is located, a large number of farmers have barns 36x60 feet, with an "L" the same size. The loft of the "L" is used for the storage of straw, and the cows run loose in the lower portion. These barns are all built on practically the same plan and are usually of the same size, and this is the only community known to the writer where this form of barn is used in this manner.

This tendency to imitate emphasizes the fact that men do not exercise sufficient originality. Because most barns are rectangular is no reason that this is the best and most economical form.

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*Special acknowledgment is made to Mr. H. E. Crouch and Mr. R. E. Brand for their assistance in working out the detailed data which are the bases for the economic comparisons of the round and rectangular barns made in this bulletin.

WHY MORE ROUND BARNS ARE NOT BUILT

In an early day when lumber was cheap, buildings were built of logs, or at least had heavy frames. Under these conditions, the rectangular barn was the one naturally used, and people have followed in the footsteps of their forefathers in continuing this form of barn. The result is that the economy and advantages of the round barn have apparently never been considered. This is because they are not obvious at first sight, and become fully apparent only after a detailed study of the construction. For these reasons, the rectangular form still continues to be built, altho it re-

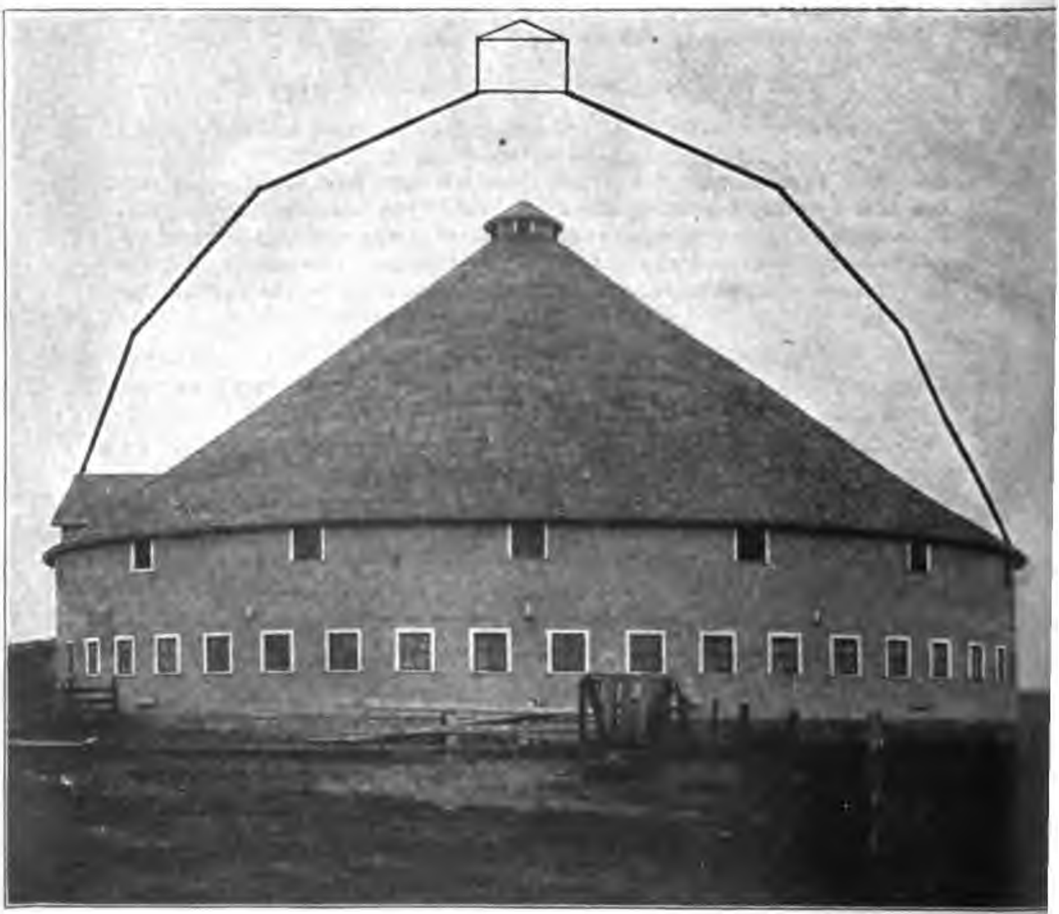

FIG. 1. BARN NO. 5. 100 FEET IN DIAMETER, SCALE 20 FEET TO ONE INCH; SHOWING INCREASED MOW CAPACITY GIVEN BY SELF-SUPPORTING ROOF.

quires much more lumber. As the price of lumber has advanced so materially in recent years, the possible saving in this material is a large item, and well worth investigating.

The objections to round barns have usually been made by those who have only a superficial knowledge of the subject, and do not really understand the relative merits of the two forms. To the writer's knowledge, there has never been published a carefully figured out, detailed comparison of a properly constructed circular barn with the rectangular barn.

The difficulty with most round barns that have been built, thus far, is that they do not have a self-supporting roof, and consequently lose many of the advantages of a properly constructed round barn. This is the principal reason why round barns have not become more popular. A straight roof necessarily requires many supports in the barn below. These are both costly and inconvenient, and make the roof no stronger than a dome-shaped, self-supporting roof which nearly doubles the capacity of the mow. See Fig. (1).

Many who have thus disregarded capacity have also wasted lumber and made a needless amount of work by chopping or hewing out the sill and plate, thus requiring more labor and lumber, besides sacrificing the greater strength of a built-up sill. Rightly constructed round barns are, however, being built to a limited extent. One contractor has erected twenty-four round barns, with self supporting roofs, in the last nine years. These barns vary in size from 40 feet in diameter with 18-foot posts to 102 feet in diameter with 30-foot posts.

Another reason for the scarcity of round barns is the difficulty in getting them built. Most carpenters hesitate to undertake the work because in the erection of a round barn the construction should be entirely different from that of the rectangular form. Many new problems present themselves, but when these are once understood, the round barn offers no more difficulties in construction than the rectangular form. It is, however, important to have a head carpenter who is accustomed to putting up round barns, as a man with ingenuity and experience can take advantage of many opportunities to save labor and material.

KIND OF BARN NEEDED

The first thing to consider in the erection of a barn is a convenient arrangement for the purpose for which it is to be used. At the University of Illinois, two years ago, a twenty-acre demonstration dairy farm was started, the sole object being to produce the largest amount of milk per acre at the least possible cost. To meet the requirements of a barn for this purpose, it became imperative to build one that was convenient for feeding and caring for the cows, economical of construction, and containing a large storage capacity in both silo and mow. These are the requirements of a barn for every practical dairyman.

A silo was needed that could be fed from the year round. With the small number of cows kept, a deep enough layer of silage could not be fed off each day to keep it good thru the summer, if the silo was more than 12 feet in diameter. As this small diameter was a necessity, it would require two silos 33 feet deep to supply enough silage. Two silos of such small diameter would not only be costly, but difficult to make stand, unless built of concrete. This difficulty was overcome by using the circular barn and placing in the center a silo which is 12 feet in diameter and 54 feet deep, thus making the one silo, with as much capacity as the two before mentioned, answer every purpose. This deep silo is an important part of the round barn, as it not only forms a support for the roof, but is protected by the barn, thus saving the cost of siding. Then, too, besides occupying the space least valuable for other purposes, it being centrally located, is in the most convenient place for feeding. The silage chute being open at the top forms a suction of air, which keeps the silage odor from the barn at milking time, and also assists in ventilation when the door to the chute is open.

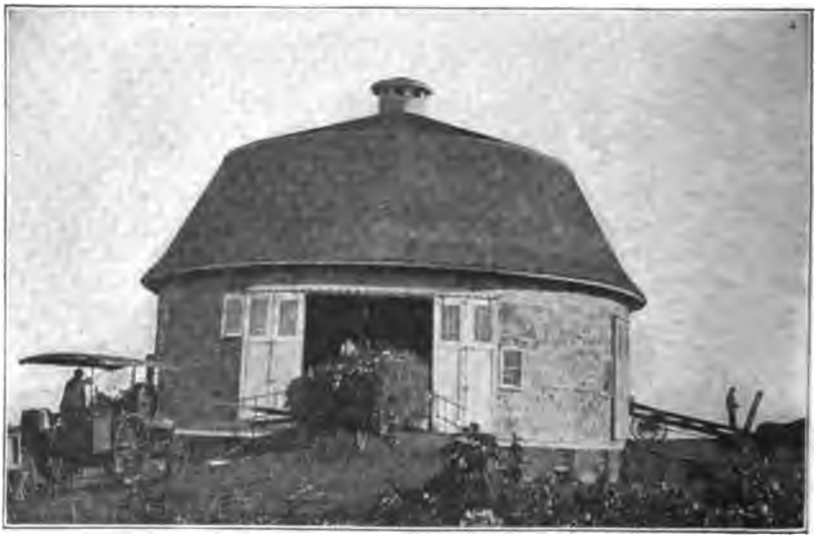

FIG. 2. FILLING THE SILO.

ADVANTAGES OF THE ROUND BARN

The points of superiority that the round dairy barn shows over the rectangular form are convenience, strength, and cheapness.

ROUND BARN MOST CONVENIENT

Considering that the barn on a dairy farm is used twice every day in the year, and that for six months each year the cows occupy it almost continuously, and that during this time a large amount of the labor of the farm is done inside the barn, it is evident that the question of its convenience is a vital one. The amount of time and strength wasted in useless labor in poorly arranged buildings is appalling. People do not stop to consider the saving in a year or a lifetime by having the barn so conveniently arranged that there is a saving of only a few seconds on each task that has to be done two or three times every day.

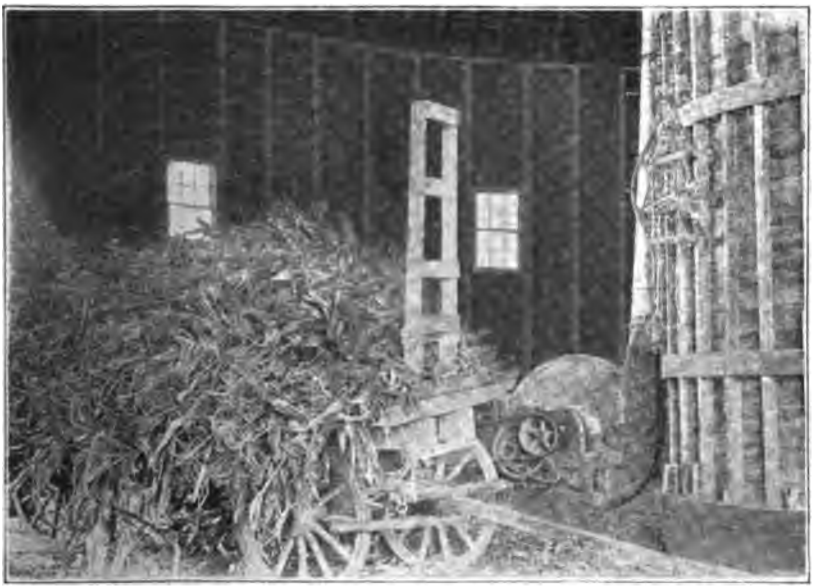

FIG. 3. INTERIOR OF BARN, SECOND FLOOR, SHOWING SILO AND LOCATION OF ENSILAGE CUTTER. (TEAM UNHITCHED TO SHOW CUTTER.)

The round barn has a special advantage in the work of distributing silage to the cows. The feeding commences at the chute where it is thrown down, and is continued around the circle, ending with the silage cart at the chute again, ready for the next feeding. The same thing is true in feeding hay and grain.

Still another great advantage is the large unobstructed hay mow. With the self-supporting roof, there are no timbers whatever obstructing the mow, which means no dragging of hay around posts or over girders. The hay carrier runs on a circular track around the mow, midway betwen the silo and the outside wall, and drops the hay at any desired point, thus in no case does the hay have to be moved but a few feet, which means a saving of much labor in the mowing.

To successfully embody all of the above discussed advantages in a dairy barn is one of the large problems in milk production. In a careful study of the barn question it soon became apparent that it was impossible to embody all of the requirements advantageously in anything but a circular form of building, and the 60-foot round barn, which is here described, was built.

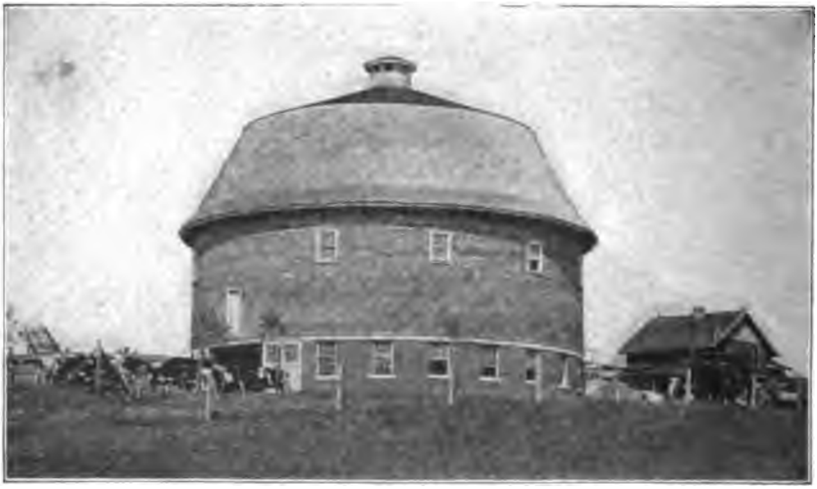

FIG. 4. SOUTH VIEW, SHOWING WELL LIGHTED STABLE.

CIRCULAR CONSTRUCTION THE STRONGEST

The circular construction is the strongest, because it takes advantage of the lineal, instead of the breaking strength of the lumber. Each row of boards running around the barn forms a hoop that holds the barn together A barrel, properly hooped and headed, is almost indestructible, and much stronger than a box, altho the hoops are small. This strength is because the stress comes on the hoops in a lineal direction. Any piece of timber is many times stronger on a lineal pull than on a breaking stress. Take for example a No. 1 yellow pine 2x6, 16 feet long, with an actual cross section of 1⅝x5⅝ inches. If placed on edge and supported at the ends, as a joist, the limit of safety for a load evenly distributed is 642 pounds, while the limit of safety for a load in the lineal direction of the same piece of timber is 12,800 pounds, or twenty times as great.

All exposed surfaces of a round barn are circular, as both the sides and roof are arched, which is the strongest form of construction to resist wind pressure; besides, the wind, in striking it, glances off and can get no direct hold on the walls or roof, as it can on the flat sides or gable ends of a rectangular structure. If the lumber is properly placed in a round barn, much of it will perform two or more functions. Every row of siding boards running around the building serves also as a brace, and the same is true of the roof boards and the arched rafters. If the siding is put on vertically and the roof built dome shaped, no scaffolding is required inside or out. These are points of economy in the round construction.

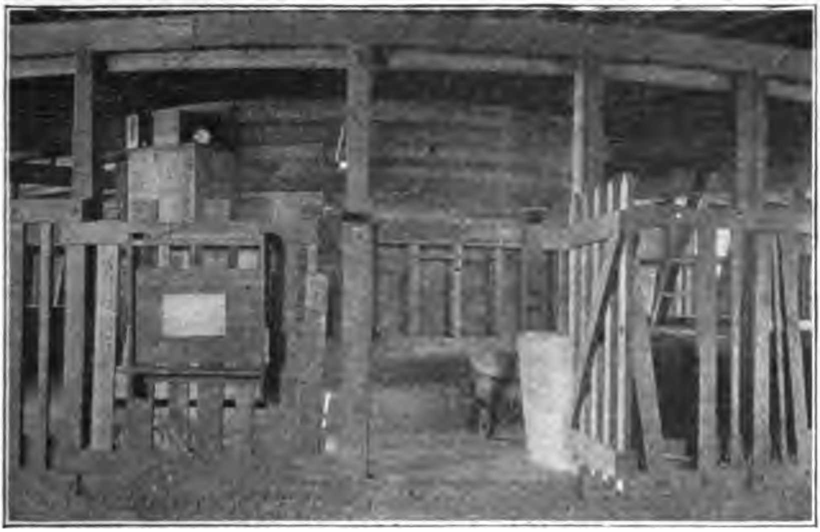

FIG. 5. IN COW STABLE, SHOWING SILO AND FEED ALLEY IN CENTER OF BARN; STANCHIONS ON RIGHT, MILK SCALES AND RECORD SHEET ON LEFT.

RECTANGULAR BARNS REQUIRE 34 TO 58 PERCENT MORE MATERIAL

In order to compare the amount and cost of material in round and rectangular barns, the following figures have been carefully worked out by an expert barn builder. Two comparisons, based

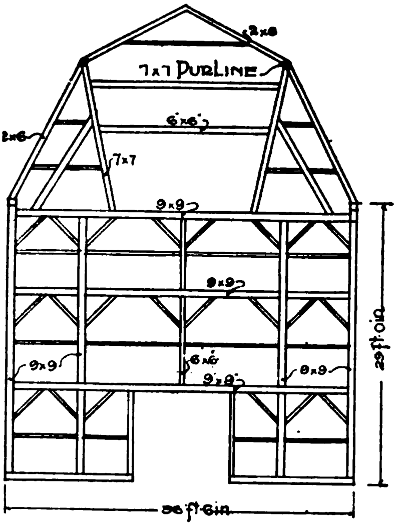

FIG. 6. SHOWING CONSTRUCTION OF MORTISE FRAME BARN, END VIEW.

on wood construction thruout, are made, in which round barns 60 feet and 90 feet in diameter are compared with both plank and mortise frame rectangular barns containing the same number of square feet of floor space, respectively. Since the most practical width of a rectangular dairy barn is 36 feet, its length will depend upon the number of square feet required in the barn.

Figures 6 to 9 are side and end views, showing the detail construction and size of the timbers of the plank frame and mortise frame barns here figured. The detailed figures of the lumber bills for each of these barns were carefully worked out, but are too voluminous for publication here. The total number of feet of each kind of lumber required is given in Tables 1A and 1B. Since the proportion of the different kinds of lumber and shingles varied for the different barns, to draw an exact comparison it was

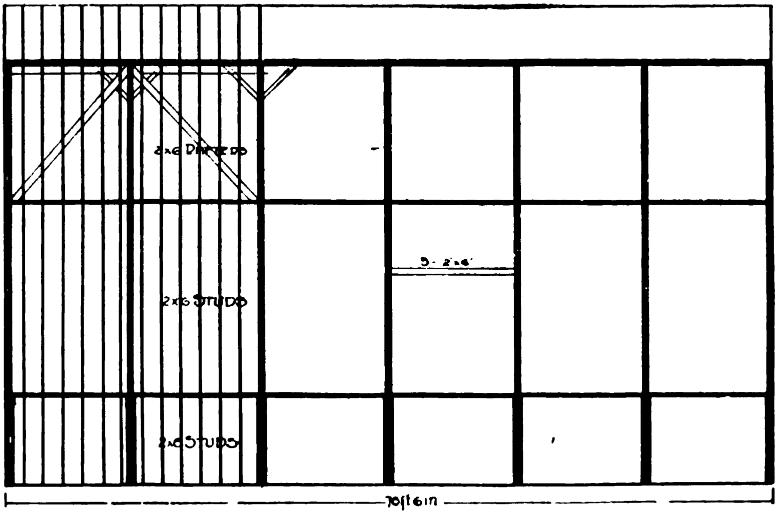

FIG. 7. SHOWING CONSTRUCTION OF PLANK FRAME BARN, SIDE VIEW.

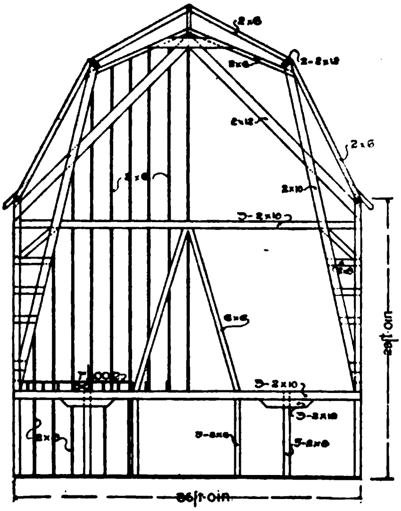

FIG. 8. SHOWING CONSTRUCTION OF PLANK FRAME BARN, END VIEW.

necessary to base it upon the money value, and for this purpose the total cost of lumber has been figured in each case. The lumber values used thruout are the best average prices that could be obtained. As the same prices are used for the material of all the barns, the comparisons of cost are correct, altho these exact prices will not hold for all localities and all times.

Since a silo cannot be economically built inside of a rectangular barn, the first comparison is made with the barns simply enclosed, altho one of the chief advantages of a round barn is the deep silo which it is possible to build so economically in the center.

Another item of economy in the circular barn is less framing lumber. This form has the strongest possible construction with the least lumber in the frame, and the least bracing, not a single

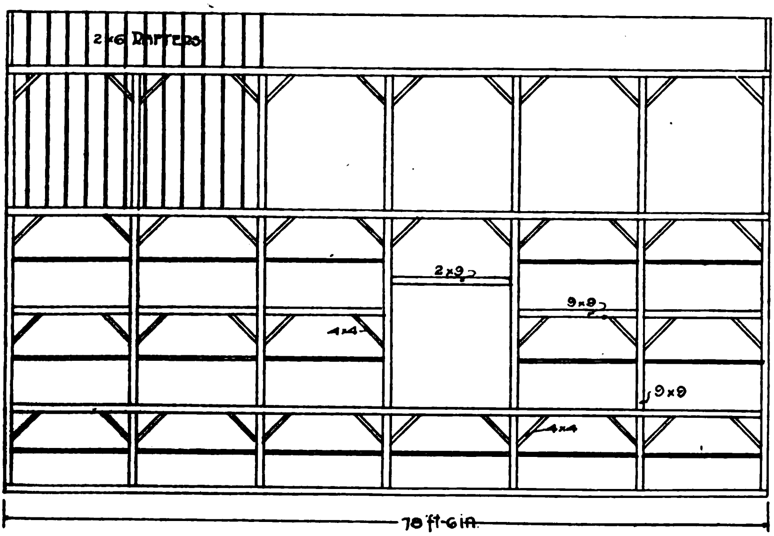

FIG. 9. SHOWING CONSTRUCTION OF MORTISE FRAME BARN, SIDE VIEW.

TABLE 1A.—A COMPARISON OF THE COST OF MATERIAL IN ROUND AND RECTANGULAR BARNS OF THE SAME AREA, *Not Including* FOUNDATION AND SILOS

	Round barn, 60 feet in diameter	Rectangular barn, 36 x 78½ ft.	
		Plank frame	Mortise frame
Framing lumber,	13,976 ft. @ $25=$349.40	19,833 ft. @ $25=$495.83	29,074 ft. @ $25=$726.85
Sheathing, siding and flooring,	12,971 ft. @ $22= 285.36	15,355 ft. @ $22= 337.81	15,355 ft. @ $22= 337.81
Shingles,	44,000 @ $3.75 = 165.00	45,000 @ $3.75 = 168.75	45,000 @ $3.75 = 168.75
Bolts,		20.88	
Total cost of lumber,	**$799.76**	**$1023.27**	**$1233.41**
Content, cubic feet,	**117,669**	**117,138**	**117,138**

TABLE 1B.

	Round barn, 90 feet in diameter	Rectangular barn, 36 x 176¾ ft.	
		Plank frame	Mortise frame
Framing lumber,	30,899 ft. @ $25=$772.48	38,815 ft. @ $25=$970.38	59,481 ft. @ $25=$1487.03
Sheathing, siding and flooring.	22,375 ft. @ 22= 492.25	28,547 ft. @ $22= 628.03	28,547 ft. @ $22= 628.03
Shingles,	97,000 @ $3.75 = 363.75	102,000 @ $3.75= 382.50	102,000 @ $3.75= 382.50
Bolts,		26.76	
Total cost of lumber,	**$1628.48**	**$2007.67**	**$2497.56**
Content, cubic feet,	**322,952**	**270,570**	**270,570**

timber larger than a 2x6 being required above the sill. The arched circular roof requires no supports, and no scaffolding is needed inside during its construction.

The accompanying tables show the comparative amount and value of lumber and cubical content in round barns 60 and 90 feet in diameter, and rectangular barns of equal area and height of posts.

ROUND AND RECTANGULAR BARNS COMPARED

In comparing the 60-foot round barn with a rectangular barn of the same area, the two barns should afford the cows the same amount of space on the platform. Allowing each cow in the 60-foot round barn 3 feet 6 inches in width at the rear of the platform, it will accommodate 40 cows and leave space for two passage ways. But in a rectangular barn, only 3 feet 4 inches of platform space need be allowed for each cow, and the 78½ foot barn, with two 3-foot passage ways across it for convenience in feeding, will accommodate 42 cows. While the rectangular barn has stall room for two more cows, the round barn contains space in the center for a silo 18 feet in diameter.

The floor space and cubical content of the round barn 60 feet in diameter, and the rectangular barn compared with it in these tables, are practically the same, and the barns are therefore directly comparable. This being true, the percentages which were figured from the complete bills of material for these barns show the exact saving in lumber on the 60-foot round barn over the plank and mortise frame rectangular barns 36x78½ feet. The lumber bills of the rectangular barns show an increase in cost of 28 percent for the plank frame and 54 percent for the mortise frame. The round barn, 60 feet in diameter, contains 188½, and the rectangular barn 225 lineal feet of wall. The rectangular barn has, therefore, 22 percent more lineal feet of outside barn wall, requiring a proportional increase in both paint and foundation.

The 176¾-foot rectangular barn would hold 100 cows, allowing each cow 3 feet 4 inches in width and providing for 3 passage ways of 3 feet each across the barn.

The 90-foot round barn would hold 100 cows in two rows headed together, 65 of which would be in the outer circle, and have 3 feet 6 inches each in width at the gutter. This leaves sufficient room for feed alleys and walks, and two passage ways, one three feet and the other seven feet wide for the manure and feed carriers. All of this is outside of a central space for a silo 20 feet in diameter and 71 feet high, with a capacity for 620 tons of silage, and in the mow there would still be an excess, above the capacity of the rectangular barn, of 33,000 cubic feet, which would

TABLE 2A.—A COMPARISON OF THE COST OF MATERIAL IN ROUND AND RECTANGULAR BARNS, *Including* FOUNDATION AND SILOS.

	Round barn, 60 feet in diameter	Rectangular barn, 36 x 78½ ft.	
		Plank frame	Mortise frame
Lumber in barn, Material in foundation, Material in silo,	$799 76 86.89 159.01	$1023.27 105.90 295.26	$1233.41 105.90 295.26
Total cost of material in barn,	**$1045.66**	**$1424.43**	**$1634.57**
Actual money saved,		**$378.77**	**$588.91**
Proportional cost,	**100%**	**136%**	**156%**

TABLE 2B.

	Round barn, 90 feet in diameter	Rectangular barn, 36 x 176¾ ft.	
		Plank frame	Mortise frame
Lumber in barn, Material in foundation, Material in silo,	$1628.48 130.35 265.00	$2007.67 196.80 513.52	$2497.56 196.80 513.52
Total cost of material in barn,	**$2023.83**	**$2717.99**	**$3207.88**
Actual money saved,		**$694.16**	**$1184.05**
Proportional cost,	**100%**	**134%**	**158%**

hold 66 tons of hay, or as much as the entire mow of a barn 32x36 feet with 20-foot posts.

The square feet of floor space in the round barn 90 feet in diameter and rectangular barn 36x176¾ feet are the same, but the cubical content of the former is more than that of the latter. The increase in the lumber bill is 23 percent in the plank frame and 53 percent in the mortise frame barn. The round barn 90 feet in diameter contains 283 and the rectangular barn 426 lineal feet of wall. The rectangular barn has, therefore, 50 percent more lineal feet of outside barn wall, requiring a proportional increase in both paint and foundation.

The smaller surface on the outside wall of the round barn requires less paint and makes a proportional saving in keeping the round barn painted in after years.

ROUND AND RECTANGULAR BARNS, *Including Silos,* COMPARED

Owing to the fact that a silo is a necessity for the most economical production of milk, a barn is not complete for a dairyman's purpose unless it includes a silo with capacity to store sufficient silage for the herd. In the case of the round barn, the silo is most economically built inside, but in the rectangular form would cause a waste of space, and for that reason is best erected outside. Therefore, in comparing a round dairy barn with a rectangular dairy barn, silos should be included.

In figuring the cost of materials in the silos for the round and rectangular barns, the capacity needed in each case was determined in the following manner: Allowing 40 pounds of silage per cow per day for 7 winter months and 25 pounds per cow per day for 3 months during the summer, would require for 40 cows 220 tons; then allowing one-eighth for waste would make the silage requirement 248 tons. As the silo in the round barn 60 feet in diameter is 53 feet deep, it would need to be only 16 feet in diameter to hold 250 tons. This diameter is sufficiently small to allow summer feeding without waste. To erect a silo outside of a barn, with sufficient stability to stand well, the height above ground should not be much more than twice the diameter, and in order to avoid waste for summer feeding, the diameter should not be greater than 16 feet for a herd of 40 cows. In order that a deep enough layer of silage can be fed off each day during the summer to avoid waste, it is evident that to store 250 tons of silage outside the barn, two silos would be required. One of these should be 16 feet in diameter and 36 feet deep, holding 154 tons, and the other 13 feet in diameter and 36 feet deep, holding 102 tons, making a total silo capacity of 256 tons.

As the large barns hold 100 cows, the same allowance of silage per cow for the season would require silo capacity for 620 tons. As the silo in the round barn 90 feet in diameter would be 71 feet deep, it would need to be only 20 feet in diameter to hold 620 tons. To store 620 tons of silage in silos built outside the rectangular barn would require two silos, each 20 feet in diameter and 44 feet deep.* These are the sizes on which the figures for cost of silos of the Gurler type, given in Tables 2A and 2B, were used.

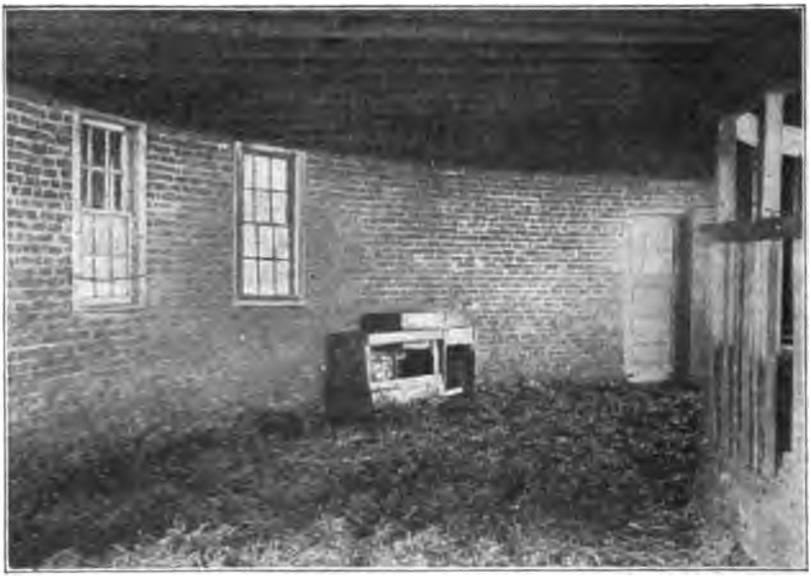

FIG. 10. INTERIOR OF COW STABLE, SHOWING WATER TROUGH WITH FLOAT VALVE, SALT BOX, AND DOOR INTO DAIRY.

The table (page 12) is the final summing up of the cost of all the material for the completed dairy barns, with silos, and shows a saving of from 34 to 58 percent in favor of the round barn and silo, or an actual money saving in this case of from $379 to $1184, depending upon the size and construction of the barns.

Thoughtlessly, men go on building rectangular barns, but what would this reckless disregard of a possible saving of 34 to 58 percent mean in a year's business on the farm? Some illustrations may help us to understand what this money saved in building a round barn really amounts to, and its convenience is also a great saving. If the dairyman discarded the idea of a rectangular barn and built a round barn instead, he could take the money thus saved and buy one of the best pure-bred sires for his herd, and also three to ten pure-bred heifers or fine grade cows. Either of these purchases might double the profit of the herd. Or, this saving, properly applied, would purchase many labor-saving devices which would make life less of a drudgery on many dairy farms. Is not such a saving worth while?

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*Since the deeper the silo the more firmly the silage packs, one silo 71 feet deep will hold as much as two silos of the same diameter and 44 feet deep.

When the comparative cost and merit of two constructions are known, it is a poor financier who will pay extra for the one which is inferior. If a man received bids from contractors for a building, he would be a foolish man who would accept one which is from 34 to 58 percent higher than the lowest bidder, especially when he knew the lowest bidder would put up the most convenient and substantial building.

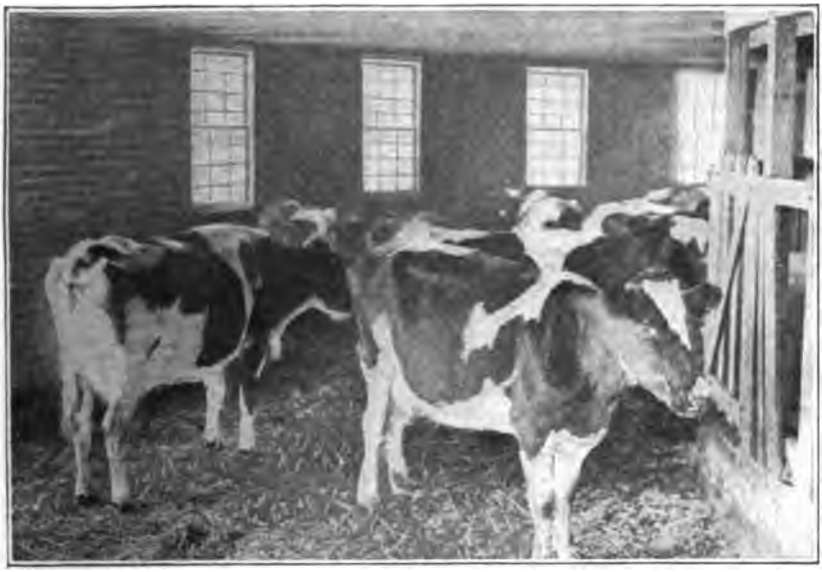

FIG. 11. COW COMFORT IN A ROUND BARN.

DISADVANTAGES OF THE ROUND DAIRY BARN

The disadvantages of the round dairy barn are, that it cannot be enlarged by building on as readily as can the rectangular form, but as the round barn may be built higher to the eaves than a rectangular barn 36 feet wide, provision can be made for the growth of the herd by building so as to put cows in the second story and still leave sufficient mow room for hay.

The objection is frequently raised that a round barn is difficult to light. This difficulty is entirely overcome in a barn 90 feet or less in diameter, if a sufficient number of properly spaced windows are used. See Figs. 4 and 30. With the same number of windows, the light is more evenly distributed in a round barn and the sun can shine directly into some portion at all hours of the day during the winter.

The objection has been raised that rectangular objects cannot be placed in a circle without a waste of space, but this does not apply to a dairy barn, as the storage of hay and grain depends upon cubical content, alone, and silos should always be circular, no matter where built. Cows, when lying down, are decidedly wedge-shaped, requiring much less space in front than behind. The objection may be raised, with round barns large enough for two rows of cows, that the row headed out does not use the space as economically as in the rectangular form, because a cow needs more width at the rear of the platform than at the manger. Where there are two rows of cows, the inner row is usually headed out, and as only about one-third of the cows are in this row, this loss of space is counterbalanced by the large number of cows in the outer circle using the space more economically than they do in the rectangular barn.

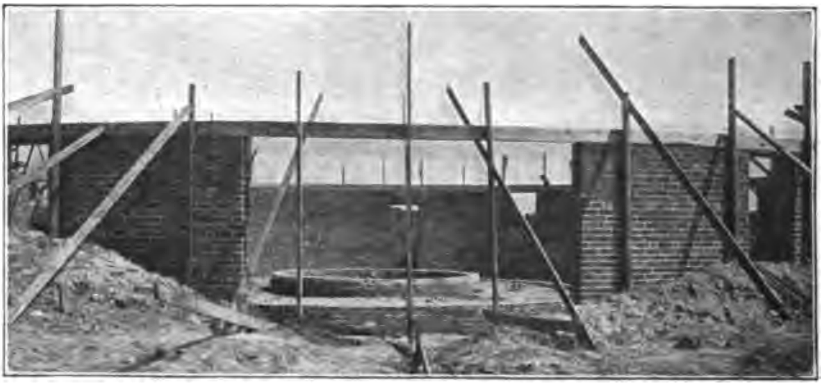

FIG. 12. FIRST STORY WALL, AND FOUNDATION FOR SILO, FEED ALLEY, AND MANGER; SILL IN PLACE, READY FOR JOISTS AND STUDS.

Box stalls cannot be as conveniently arranged, but in a one-row barn, gates hung on the outside and swung around to the manger, form stalls for cows at freshening time, and in a barn with two rows, box stalls can be arranged in the inner circle.

HOW THE ROUND BARN AT THE UNIVERSITY WAS BUILT

The barn is located on the side of a hill, sloping gently to the south and east. With this location, it was an advantage to excavate 5 feet deep on the northwest and run out to the surface of the ground on the southeast.

The footing for the foundation is 18 inches wide. A ten-inch brick wall was carried up nine feet above the stable floor. This wall contains a 2-inch air space to prevent moisture from condensing on the inner wall and making the barn damp. This is an important point, as barns with a solid stone or brick wall are very objectionable on account of dampness. It has been proven by two years' use that this difficulty is entirely obviated by the air space in the wall.

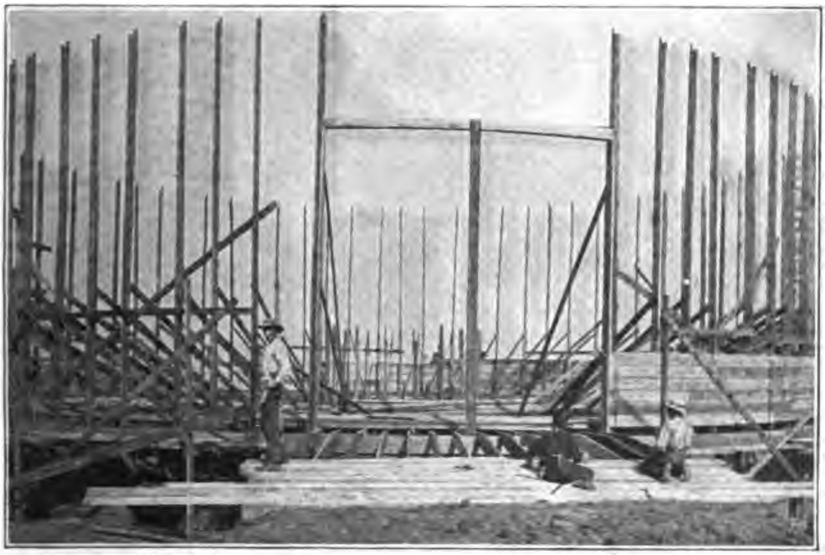

Fig. 13. Showing temporary bracing to hold studs in place while ship lap ceiling is nailed on.

The foundation for the manger and feed alley is built up 2 feet above the stable floor. The foundation for the silo extends 4 feet below the stable floor and is continued 9 inches above the floor in the feed alley. This silo wall, together with the foundation under the manger, forms the foundation for the center supports of the barn. Fig. 12 shows the foundation completed.

The silo, which is the Gurler type, was then started and carried up with the barn. It was built by placing 2x4 studs around the circle, one foot on centers, and ceiling inside with ½x6-inch lumber. This ½-inch lumber was obtained by re-sawing 1x6 yellow pine fencing. Common lath were then put on horizontally in the regular way inside, without furring out, and plastered with rich cement plaster.

The sill of the barn is 6x6, made up of 1x6s, and built on top of the wall. Building it up in this manner makes a stronger sill than can be obtained in any other way, as it forms a continuous hoop around the barn.

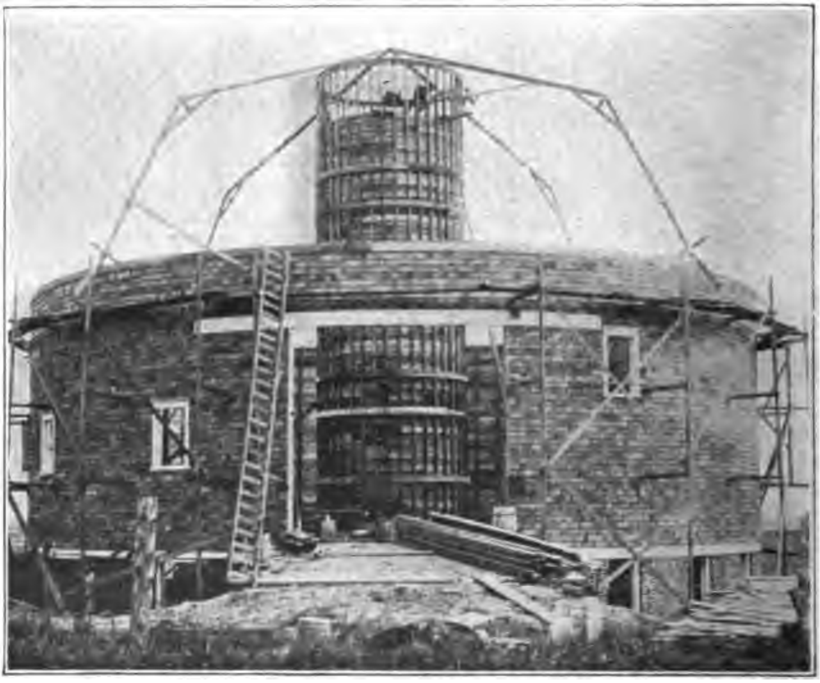

FIG. 14. SHOWING HEIGHT AND CONSTRUCTION OF SILO, SIDING COMPLETED, AND FOUR MAIN RAFTERS IN PLACE.

The joists are 2x12s notched 6 inches to fit the sill, so that the outer ends rest on both the sill and the brick wall. The outer span of joists is 14 feet and the inner ends of these joists rest on a similar sill built of 1x6s on top of the 4x4 supports at the stanchions. The inner span of joists, between the stanchions and the silo, is 8 feet, the outer end resting on the sill over the stanchions, and the inner end on a 1½x6-inch band, made up of three ½x6-inch pieces, running around the outside of the silo. These joists are placed 2½ feet apart at the outside of the barn, and half as many joists are used in the inner span, making the joists at the silo one foot apart. The number of joists under the driveways are doubled, being only 1 foot and 3 inches apart at the outside of the barn.

The studs, which are 2x6s, 20 feet long, were then placed on the sill, about 2 feet 6 inches apart, being as evenly spaced between the windows as possible, and temporarily braced, as shown in Fig. 13, until the 8-inch ship lap ceiling could be nailed on the outside. This was carried up 5 feet to the second scaffold, and then covered to this height with shingles laid 5 inches to the weather. The scaffolding was then moved up and this process repeated until the siding was completed. The plate, made up of five 1x4s, was then built in the notch in the top of the studs shown in Fig. 13.

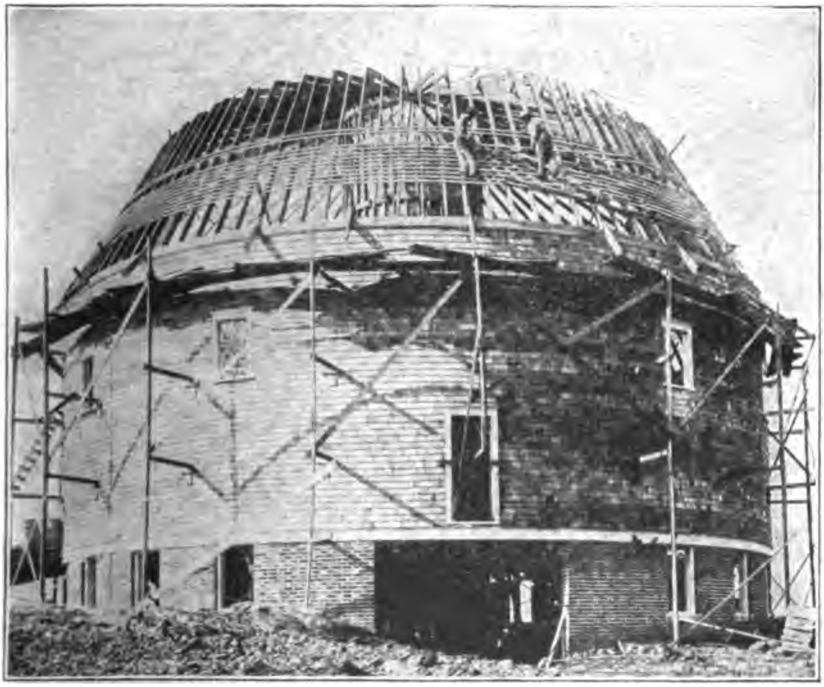

FIG. 15. SHOWING ALL RAFTERS IN PLACE AND METHOD OF SHEATHING ROOF.

The silo was completed, as before described. The rafters, which were framed on the ground, were then erected, as shown in Fig. 14, the first eight going to the center of the roof, and the

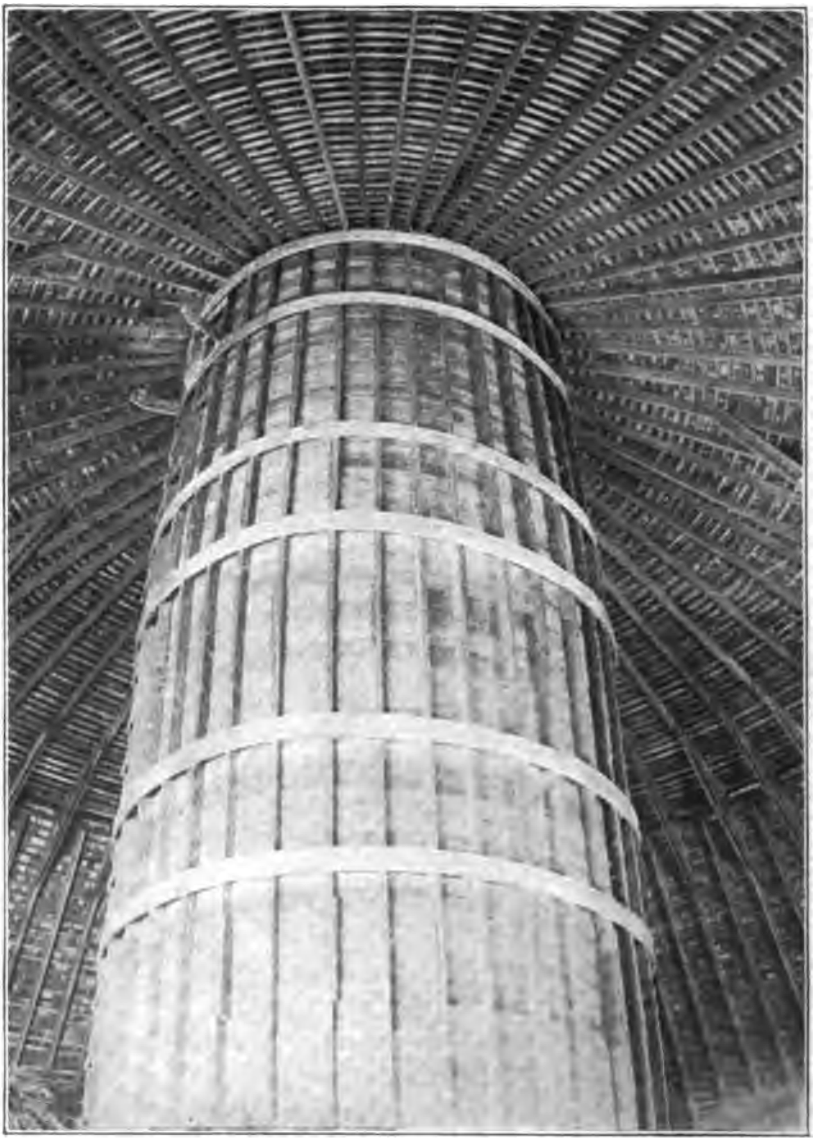

FIG. 16. SHOWING HEIGHT OF SILO, CAPACITY OF BARN, AND CONSTRUCTION OF ROOF.

remaining ones were cut to rest on the plate of the silo. There are 64 framed rafters, and these are the only ones in the upper section of the roof. At the break in the roof, a header is cut in between the framed rafters, and in the lower section a rafter is placed between these, thus making twice as many rafters in the lower section of the roof as in the upper section. After the rafters were all in place and temporarily braced, the 1x2-inch sheathing was put on, as shown in Fig 15, and the shingles, which were the best 5/2 red cedar, were laid 5 inches to the weather on the lower section of the roof, and 4 inches to the weather on the upper section, as this had less pitch. No chalk line was necessary, as the shingles were laid by the sheathing.

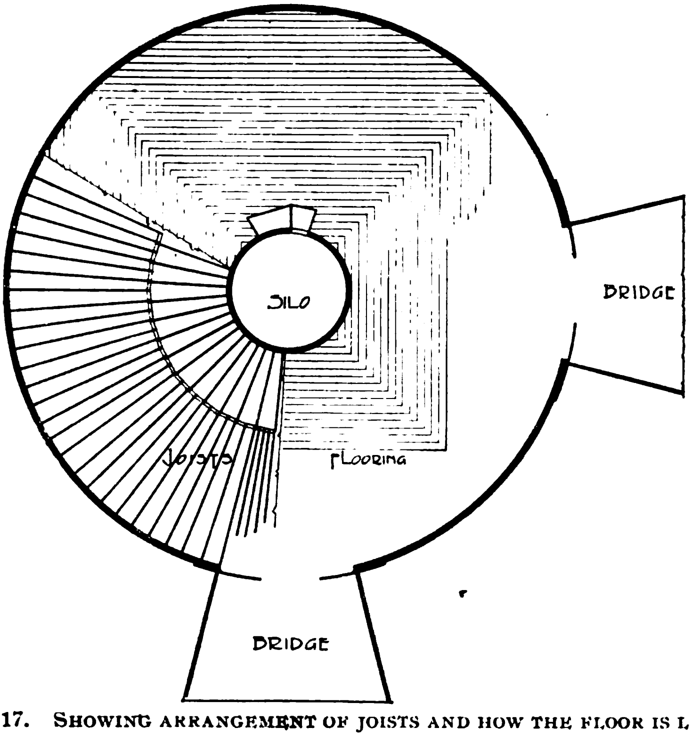

FIG. 17. SHOWING ARRANGEMENT OF JOISTS AND HOW THE FLOOR IS LAID.

The floor was made of 1x8 ship lap, laid in four directions, as shown in Fig. 17. In the driveway an extra layer of ship lap was used, making this portion of the floor 2 inches thick.

The doorways in the second story are 14 feet wide, and in the lower story 12 feet. These openings are closed by two sliding doors, each door being made of two sections, hinged together so as to follow the circular wall of the barn in opening.

The cow stable is on the ground floor, and well lighted by 16 windows having twelve 9x12 lights each. There are also six windows in the doors. The windows are placed just below the ceiling and admit an abundance of sunshine at all times of the day, which is one of the essentials of a good dairy barn.

The floor, back of the manger, is of clay, except at the door, where a small portion is covered with cement. The cows run loose

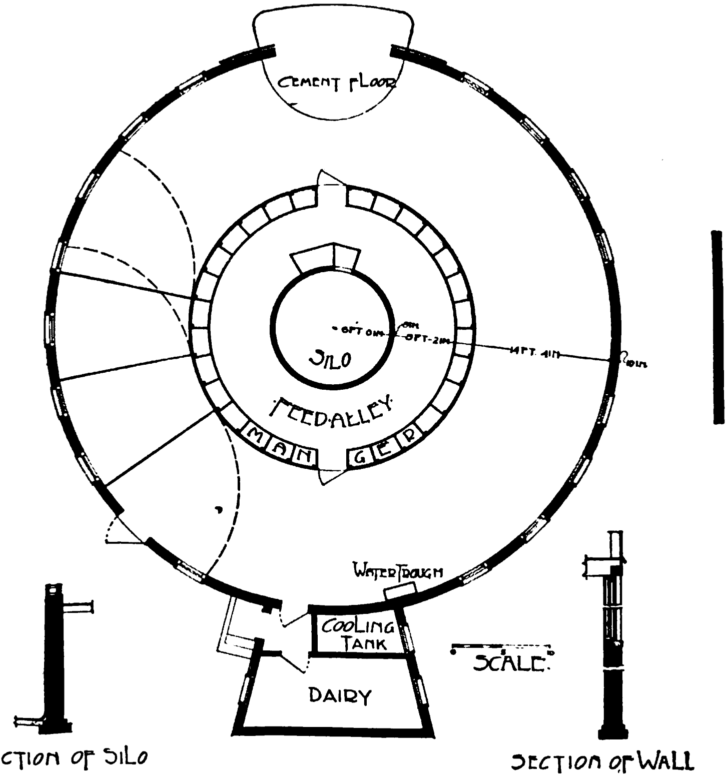

FIG. 18. SHOWING PRESENT ARRANGEMENT OF COW STABLE. THERE ARE STANCHIONS AND MANGERS FOR 28 COWS, AND 2200 SQ. FT. OF FLOOR SPACE IN WHICH THE COWS CAN RUN LOOSE. THE GATES ARE SWUNG INTO THE PRESENT POSITION WHEN BOX STALLS ARE NEEDED.

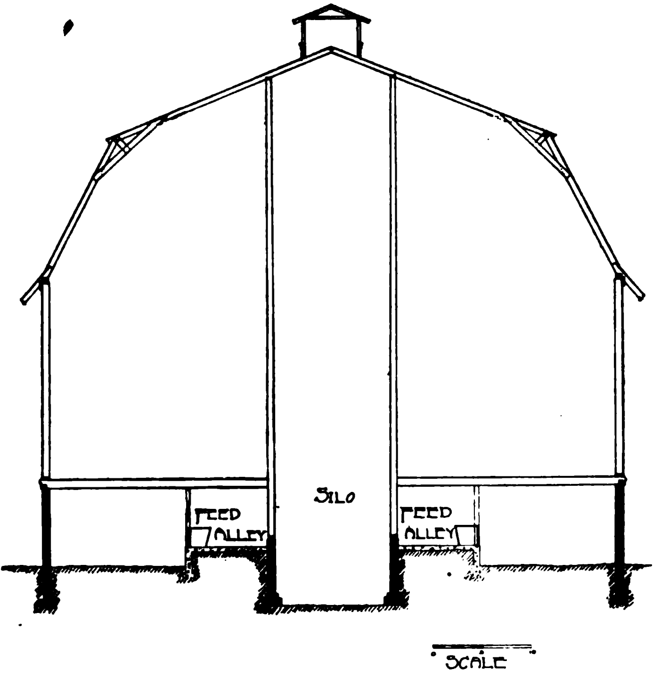

FIG. 19. SHOWING CROSS SECTION OF 60-FOOT ROUND BARN.

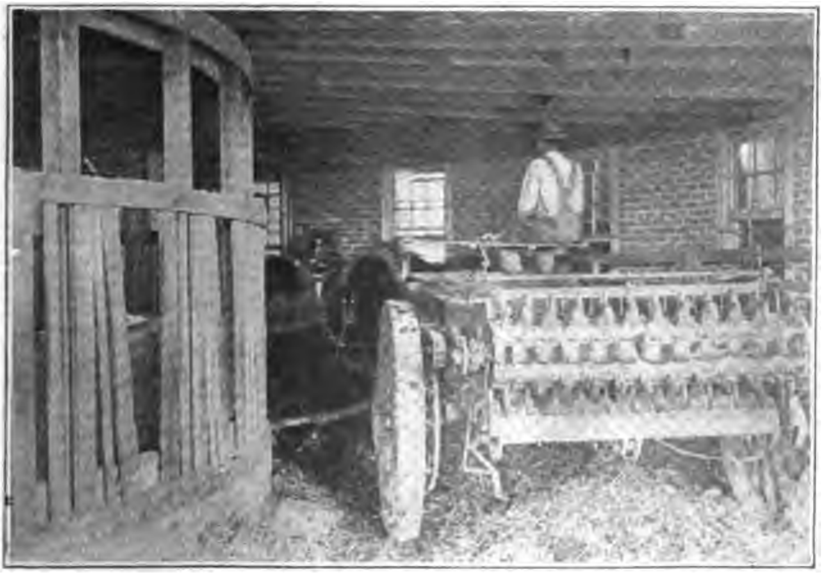

FIG. 20. CLEANING OUT COW STABLE WITH THREE-HORSE MANURE SPREADER.

except at feeding and milking time, when they are placed in rigid stanchions. It must be distinctly understood that rigid stanchions are strongly condemned as a cow tie, where cows are to remain in them all night, but as they are here used merely to hold the cow during milking, they are both economical and convenient.

Running cows loose in this manner is an excellent method, where bedding is abundant and sufficient space is available, as the cows are more comfortable, and all fertility is saved. There is no waste from leaching, as when the manure lies exposed to the weather. This method saves the labor of cleaning the stable, as the manure is loaded into the spreader and hauled directly upon the land whenever convenient, and the land is in the best condition to receive it.*

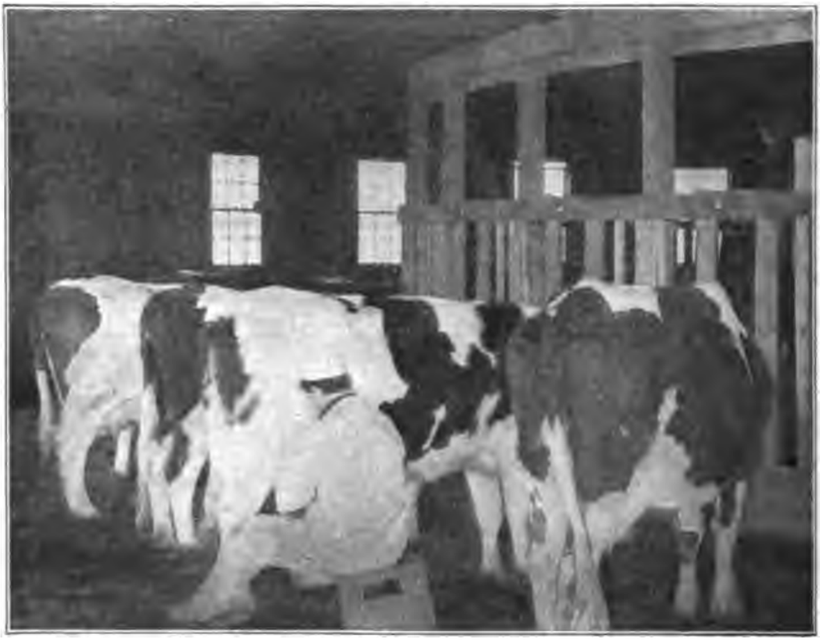

FIG. 21. COWS IN STANCHION AT MILKING TIME.

Three gates are hung on posts at the outside wall, and when box stalls are needed, these are swung around to the manger, as shown in Fig. 18. The south door in the cow stable can be closed by slatted gates, thus affording an abundance of fresh air and sunshine on nice days, without letting the cows out of the barn.

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*For a more detailed discussion of the advantages of keeping cows in this manner, see Illinois Agricultural Experiment Station Circular No. 93.

SYSTEM OF VENTILATION

The system of ventilation is the "King." To economize space and lumber, the hay chute is used for a ventilator. This chute, which extends to the cupola, is 2¼x3½ feet, having a cross section area of 8 sq. ft., which, with a good draft, is sufficient for 40 cows. In order that this combination of ventilator and hay chute prove practical, doors thru which the hay could be thrust were placed at intervals in the side of the chute. These doors are hinged at the top, opening in, and close immediately after the hay drops, thus maintaining a closed ventilator chute. The air is drawn in at the bottom, the amount being regulated by means of a sliding door in the side. As this chute is 50 feet high, it creates a strong suction.

FIG. 21. CONTINUED.

THE MILK ROOM

To economize space, the milk room, 12x16 feet, is located under the north driveway. The brick walls under the drive form the sides of this room, and the floor of the drive, which is made of 2x6s grooved on both edges, forms the roof. The grooves in the flooring were filled with white lead, and a wooden strip, fitted to fill the grooves of both planks, was driven in, forming a water-tight floor. This floor was covered with hot tar and sand ½ inch thick. The milk room is plastered on the inside, the plaster being applied directly to the brick walls, excepting in the case of the ceiling, which is lathed. The floor and cooling tank are of cement. The passage from the barn to the milk room is thru a small hallway, which is open to the outside, thus preventing the stable air getting into the milk room.

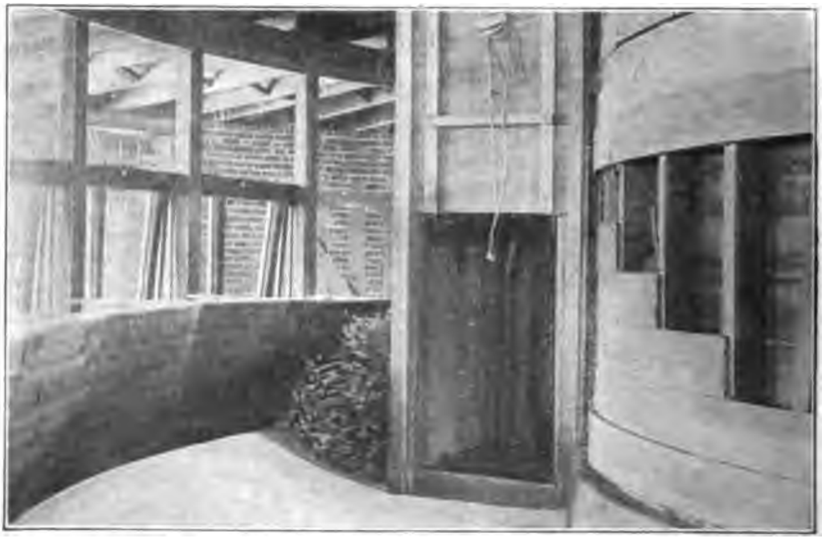

FIG. 22. FEED ALLEY, SHOWING COMBINED HAY CHUTE AND VENTILATOR. A DOOR ON THE SIDE WHICH IS HINGED AT THE BOTTOM, 3 FEET FROM THE FLOOR, IS LET IN TOWARD THE SILO, SLIDING THE HAY ONTO THE FLOOR. IN HOT WEATHER THIS OPENING TAKES THE HEAT OUT OF THE BARN; DURING THE WINTER THIS DOOR IS KEPT CLOSED AND THE VENTILATION IS REGULATED BY RAISING THE SLIDE, AS SHOWN IN THE CUT.

BARN SATISFACTORY

This round dairy barn above described has been in use for over two years at the University of Illinois, and has given entire satisfaction.

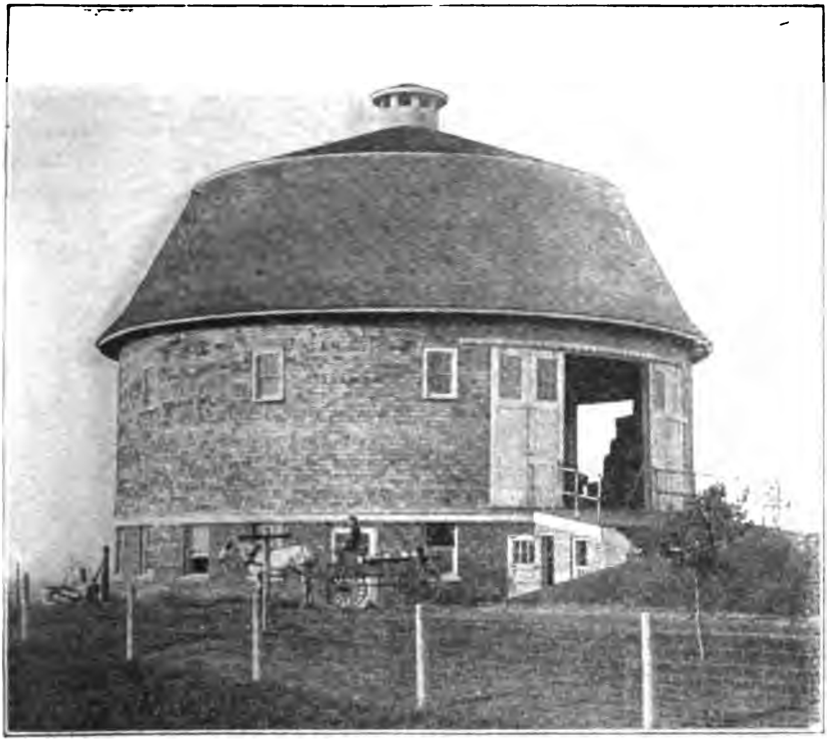

FIG. 23. NORTHEAST VIEW, SHOWING DAIRY UNDER DRIVEWAY. THE BARN IS ON THE SAME SCALE AS THE DRAWING ON PAGE 28.

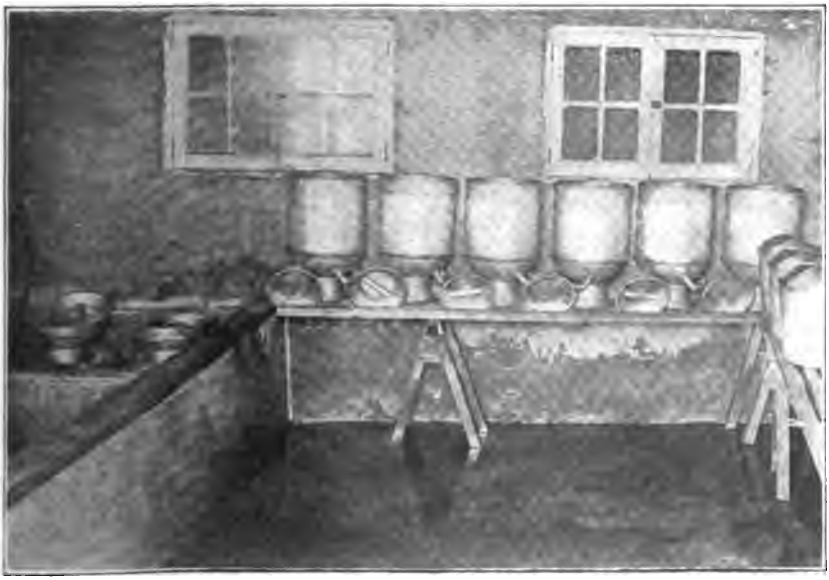

FIG. 24. INTERIOR OF DAIRY; COOLING TANK ON LEFT.

RE-ARRANGEMENT OF BARN TO ACCOMMODATE 40 COWS

If it is desired to keep cows in stalls in a round barn of this size, the circular manger can be enlarged to 38 feet in diameter, which gives room for forty cows, as shown in Fig. 25, and the silo, to hold sufficient silage to feed the year round, enlarged to 18 feet in diameter. The present mow room is sufficient to store enough hay and bedding for this number of cows.

The barn on the Twenty-acre Demonstration Dairy Farm was built this large, as it was thought it might be desired at some future time to increase the size of the farm and herd, and the barn could easily be changed to accommodate a larger herd by simply enlarging the silo, without rebuilding the barn.

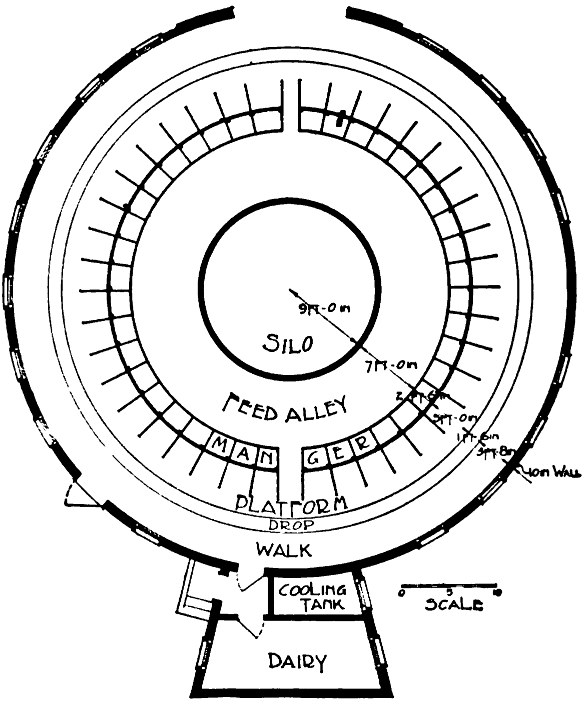

FIG. 25. SHOWING HOW THIS 60-FOOT BARN MAY BE ARRANGED TO ACCOMMODATE 40 COWS IN STALLS. TO SUPPLY THIS SIZED HERD AND THE NECESSARY YOUNG STOCK WITH SILAGE FOR EIGHT MONTHS WOULD REQUIRE A 370-TON SILO, OR ONE 18 FEET IN DIAMETER AND 56 FEET DEEP; WITH A SEVEN-FOOT FEED ALLEY AND A 2½-FOOT MANGER, THE CIRCLE AT THE STANCHIONS WOULD BE 38 FEET IN DIAMETER, OR 119⅓ FEET IN CIRCUMFERENCE; ALLOWING 4¼ FEET FOR TWO PASSAGE WAYS, THE STALLS WOULD BE 2 FEET 10½ INCHES WIDE AT THE STANCHION, AND 3 FEET 6 INCHES AT THE DROP.

ITEMIZED COST OF THIS ROUND BARN

Excavating, foundation, and first story brick wall	$904.00

Lumber:

149 pieces, 1x 4x16 Y. P.
31 " 1x 4x14 Cypress
16 " 1x 4x12
165 " 1x 6x16 Y. P.
17 " 1x 6x14 "
226 " 2x 4x12 "
20 " 2x 4x16 "
6 " 2x 4x14 "
15 " 4x 4x14 "
120 " 2x12x16 "
23 " 2x12x14 "
100 " 2x 6x20 "
144 " 2x 6x16 "
67 " 2x 6x18 "
4 " 2x 6x26 "
60 pieces, 2x 6x12 Y. P.
30 " 2x 6x22 "
4 " 2x 6x24 "
6 " 2x 8x10 "
9 " 2x 8x16 "
4 " 2x10x14 "
11 " 2x10x12 "
1 " 2x10x22 "
1 " 1x10x12 "
1 " 1x10x14 Cypress
2 " 1x12x14 "
22 " 1⅛x8x10 Cyp. S2S
2 " 1x1⅛x12x14
2 " 1x1⅛x12x16
6000 feet of 8-inch ship lap
3150 feet of 10-inch ship lap
71 M 5/2 red cedar shingles
165 Lineal feet of 2-inch Cr. molding
240 Lineal feet of Cr. molding
270 feet of 4-inch Y. P. S1S
4000 feet of 6-inch rough pine
62 feet of ⅜-inch Y. P. Ceiling
850 feet of 6-inch No. 1 flooring
230 feet of 6-inch fence flooring
56 lineal feet of ½x3-inch battening
32 lineal feet of lattice
444 lineal feet of 4-inch cypress
3 10-foot cedar posts

Total cost of lumber	$1.313.63

Mill work:

Window sash and doors	$270.00
Window and door frames	71.00
Sawing lumber for silo, roof, bridge and stanchions	29.78
Cost of hardware	96.57

Carpenter work:

Head carpenter	518 hrs. @ 40c=	$207.20	
Carpenters	1057 hrs. @ 35c=	369.95	
Common labor	429 hrs. @ 20c=	85.80	
Total cost for carpenter work			662.95

Tiling around barn and silo, sewer from dairy room, retaining wall, cement floor in alley, dairy, doorway of barn, and steps and tanks	128.54
Plastering dairy room and inside of silo	104.60
Painting	89.54
Total cost of barn	$3670.61

The cost of this barn, if built on the ordinary dairy farm, could be materially reduced without shortening the life of the barn. Owing to the conditions under which this barn was built, it was necessary to pay for hauling all material to the farm, two and one-half miles from town. All of the labor had to be hired, and as it was necessary for the men to board themselves the wages paid were proportionately higher. The farmer usually does the excavating and hauls the brick, sand, and lumber with his own teams, tends the mason, and does quite an amount of the rough work with his own help, besides boarding the men, all of which would greatly reduce the cost. The construction could also be cheapened by using drop siding to cover the outside, instead of shingles, which in this case were used over ship lap on the side walls to improve the appearance. This barn could be still further cheapened by putting hoops, five feet apart, around the studs, and covering with common 1x12 boards, put on vertically, as is done in some cases. A saving could also be made on the mill work and large doors by

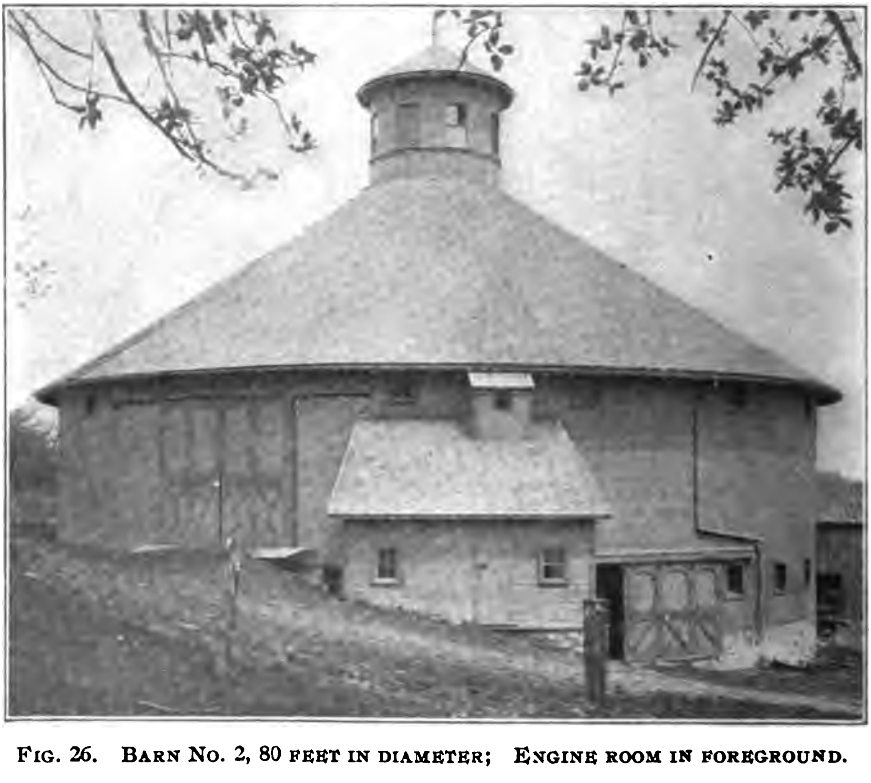

FIG. 26. BARN NO. 2, 80 FEET IN DIAMETER; ENGINE ROOM IN FOREGROUND.

having the carpenters make these plainer and leave the windows out of them.

Anyone wishing to build a round barn can get local bids on the lumber bill, and determine approximately the cost in his locality. This will vary with both the location and the year.

OTHER ROUND DAIRY BARNS

BARN NO. 2

Built 1897.

Diameter, 80 feet.

Capacity, 75 cows in 2 rows, tails together, 51 head in outer circle, 24 head in inner circle.

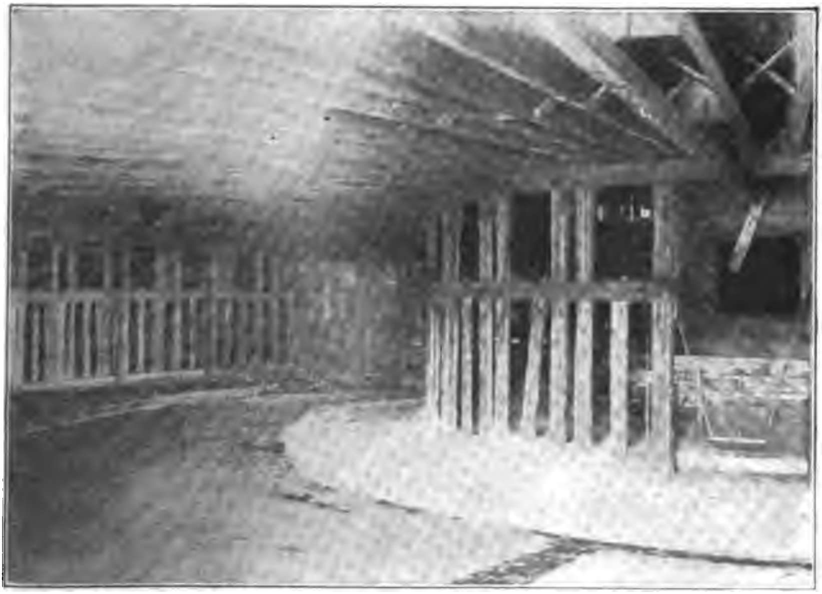

FIG. 27. INTERIOR OF BARN NO. 2, SHOWING TWO ROWS OF STANCHIONS AND DRIVE BEHIND COWS WHICH IS USED IN CLEANING BARN; SILO ON RIGHT.

Cost, $1800.

Studs, 2x6s, placed 2½ feet on center.

Supports, two 2x6s in each stanchion.

Joists, main span 3x12s, 20 feet long, placed 14 inches on center. Short spans over feed alleys, 2x10s.

Plate, 1x10-inch boards sprung around near top of studs.

Roof supports, 6x6s placed 12 feet apart. Purline plate rests on these posts and consists of 1x8s sprung to the circle.

Siding, 8-inch, put on horizontally, first story ceiled inside.

To clean out, a wagon is driven around between the two rows of cows.

The chief objection to this barn is insufficient light in the cow stable.

This barn and No. 3 are approximately the same in construction, and are more substantially built than barns No. 4 and 5.

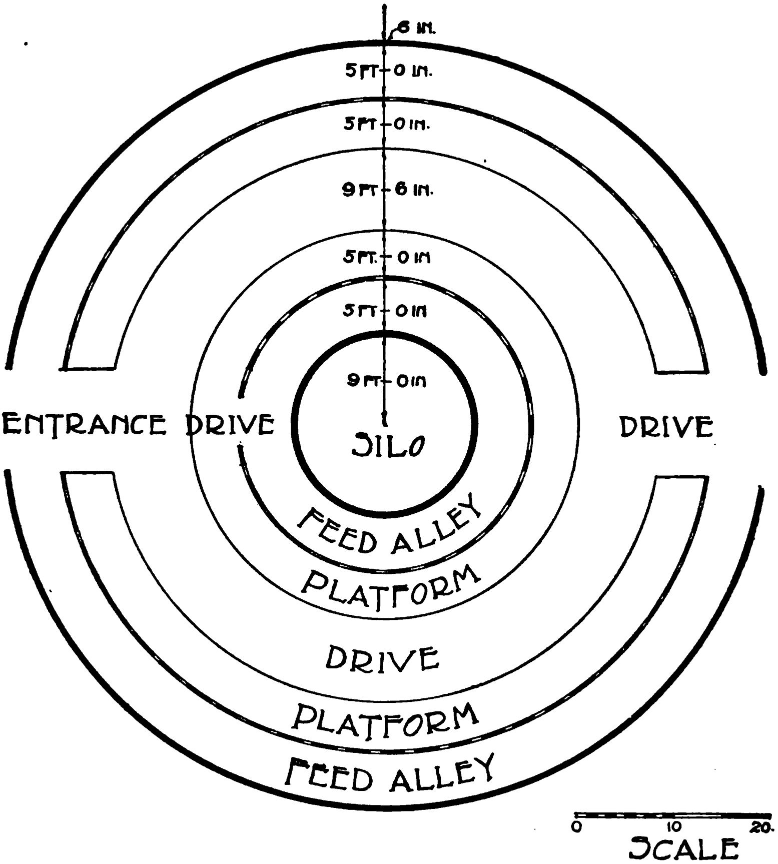

FIG. 28. ARRANGEMENT OF COW STABLE IN BARN NO. 2; TWO ROWS OF COWS TAILED TOGETHER. THE BARN IS CLEANED BY DRIVING AROUND BEHIND THE COWS.

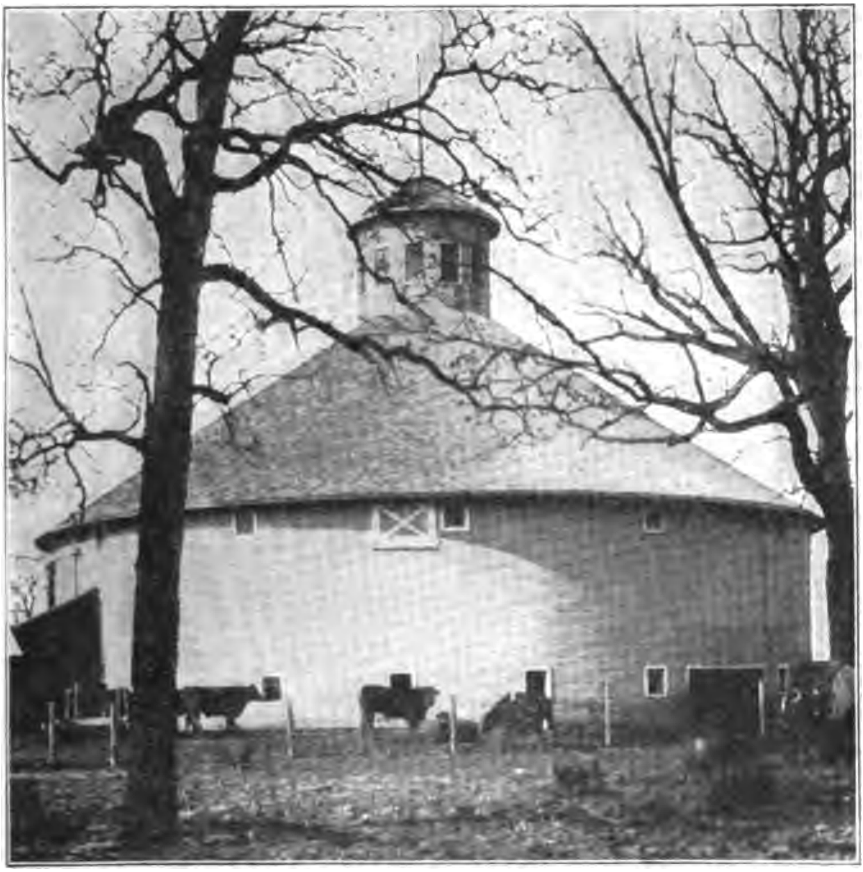

FIG. 29. BARN NO. 3, 80 FEET IN DIAMETER.

BARN NO. 4

Built in 1900.

Diameter, 90 feet.

Capacity, 105 cows, two rows heading together.

Cost, $3000.

Foundation, width at base and top, 18 inches; depth in ground, 20 inches, (not sufficient).

Sills, 2x8s, sawed in short lengths, and placed flatwise.

Studding, 20-foot 2x8s, placed 3 feet on center and toenailed to sill.

Supports, first story 4x4s placed between stanchions in each row, making two rows of supports between the outside wall and the silo; 4x4s cut to a circle placed on top of these supports. The outside span, over cows, is 13 feet 6 inches; middle span, over feed alley, 6 feet 8 inches, and inside span, over cows, 13 feet.

Joists, 2x8s placed 3 feet apart at studs on outside wall. There are as many joists in center of barn as at the outside.

Supports, second-story, consist of one row of posts running around at a point immediately under the break in the roof. These are 16 feet apart and are made of three 2x8s kept 2 inches apart by horizontal braces which run from studding near the eave thru these posts to studding in silo. See Fig. 31.

Plate, rafter is set on top of each stud, and no plate is used.

Rafters, 2x6s resting on studs at outside and on circular plate at break in roof.

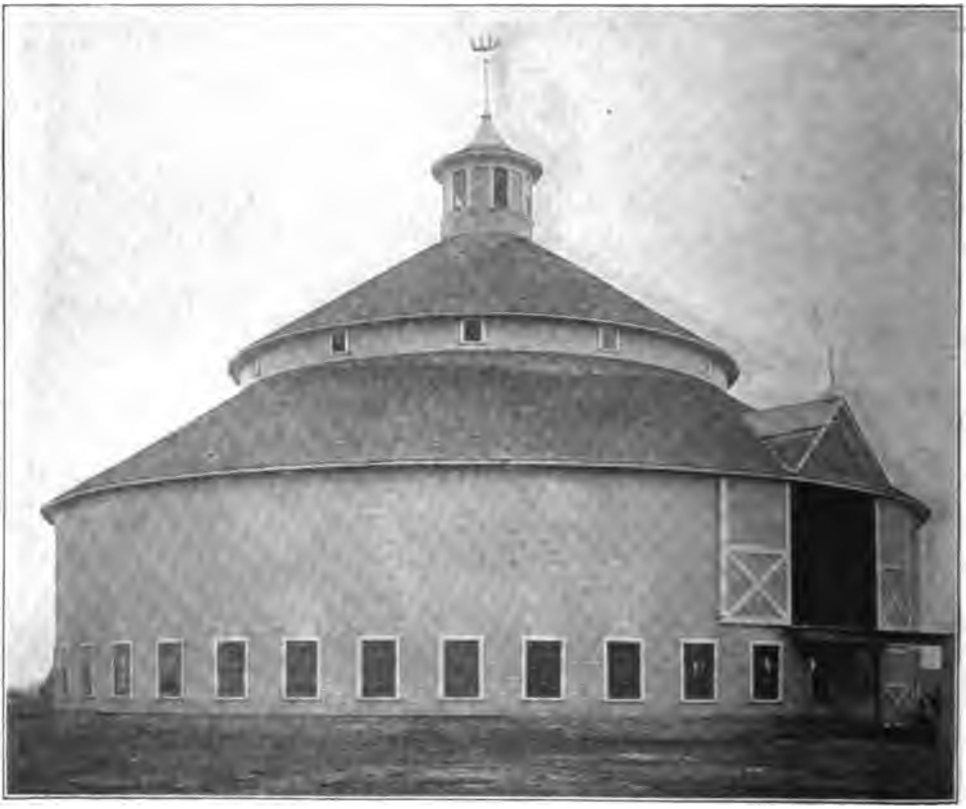

FIG. 30. BARN NO. 4, 90 FEET IN DIAMETER; ONE OF THE FEW DAIRY BARNS WITH SUFFICIENT LIGHT; SAME SCALE AS DRAWING ON PAGE 37.

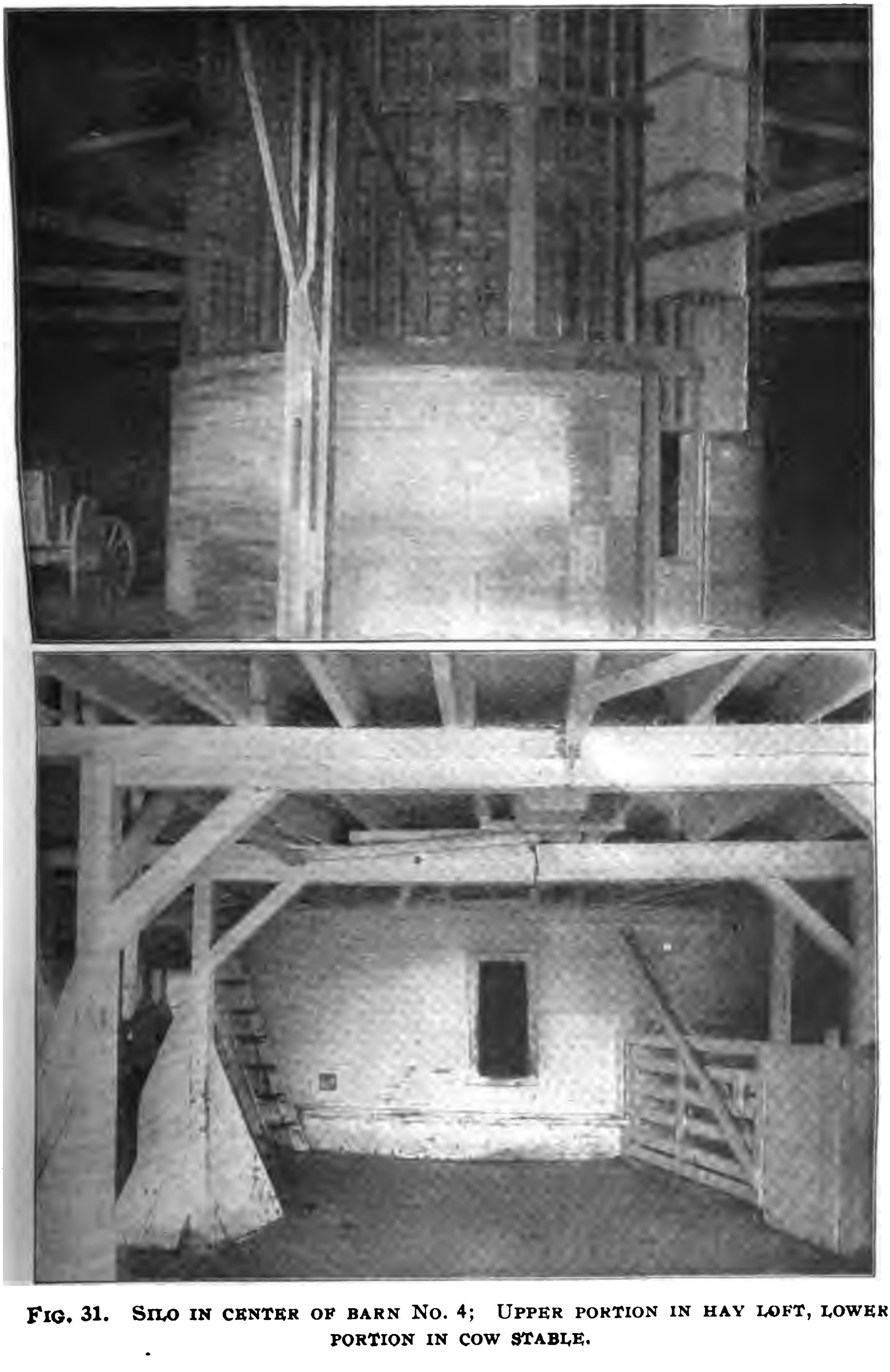

FIG. 31. SILO IN CENTER OF BARN NO. 4; UPPER PORTION IN HAY LOFT, LOWER PORTION IN COW STABLE.

Siding, 8-inch drop siding, put on horizontally, nailed with 10d nails. Ends holding well.

Windows, 12 light, 10x12 glass; one window every six feet. This gives an abundance of light in the center of the barn.

Doors, built on circle; (not satisfactory).

Silo, round; diameter, 24 feet over all; height, 53 feet, exclusive of 12-foot space for water tank on top; capacity, 500 tons.

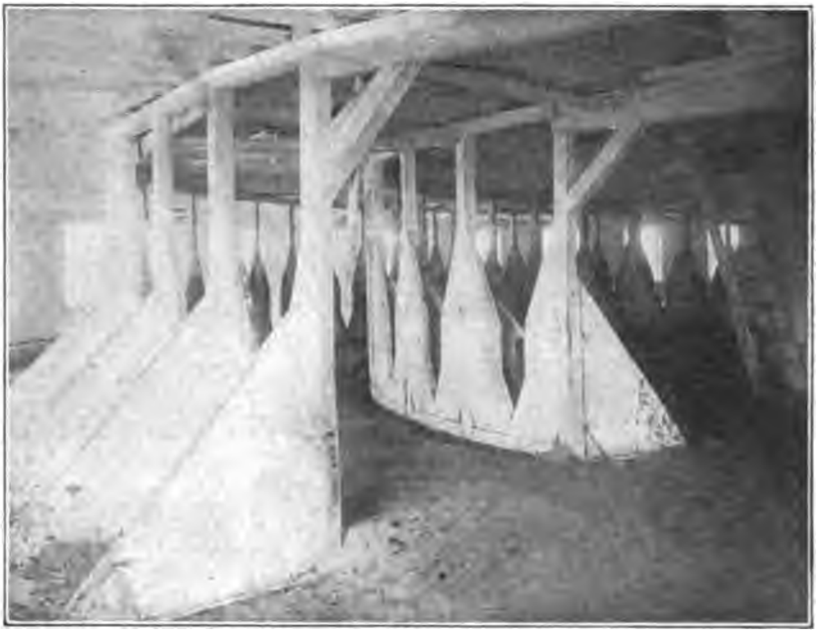

FIG. 32. INTERIOR OF BARN NO. 4, SHOWING STALLS AND FEED ALLEY.

Studs of silo, 2x4s placed 12 inches on center. Ceiled inside of studs with two thicknesses of half-inch lumber with paper between.

Remarks: Considering its size, the construction of this barn is apparently too light to be substantial, as the joists and studs are too small and too far apart, yet it has stood for nine years with no more evidence of wear than is common with any barn.

Were the owner to build again he would place the studs only 2½ feet apart and use 2x12 joists, 2½ feet apart at the outside wall. He would also use cement plaster on inside of silo.

The owner says it would have cost him as much to have built a rectangular barn without the 500-ton silo, and containing 1300 sq. ft. less floor space. In other words, he gained a 500-ton silo and 1300 sq. ft. of floor space, besides an immense amount of mow room, by building a circular barn.

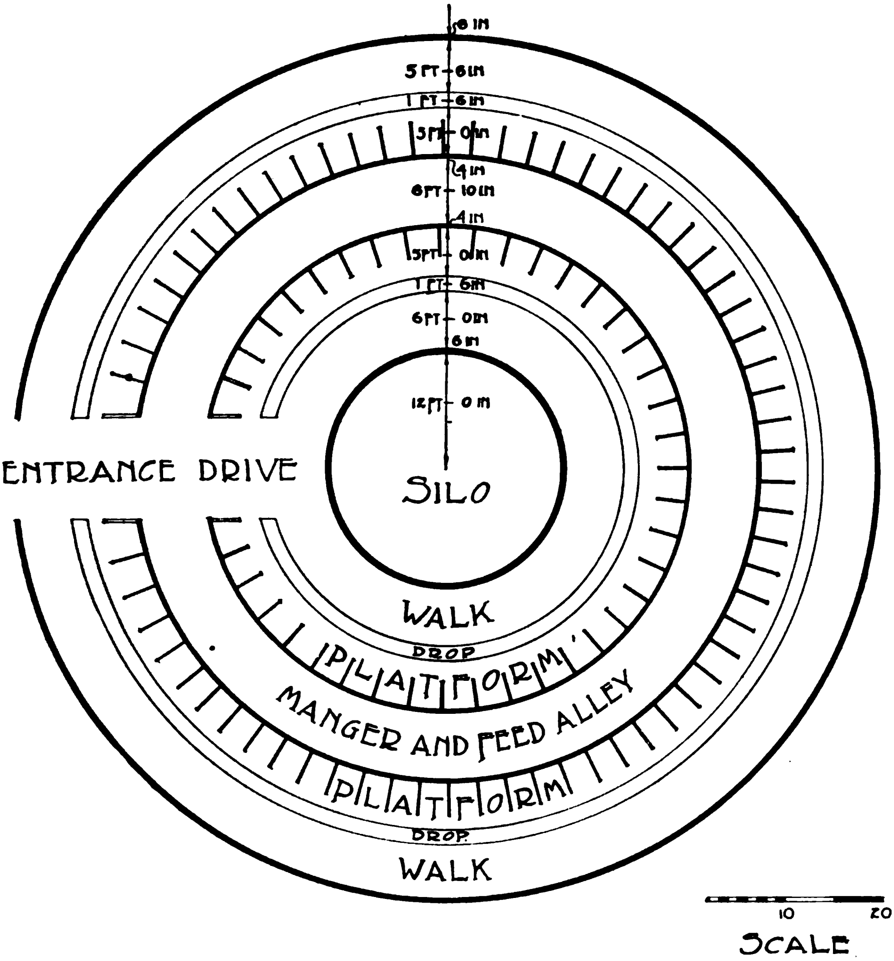

FIG. 33. ARRANGEMENT OF COW STABLE IN BARN NO. 4, 90 FEET IN DIAMETER; TWO ROWS OF COWS HEADED TOGETHER.

BARN No. 5

Built in 1906.

Diameter, 100 feet.

Capacity, 115 cows.

Cost, $3400.

Studding, 16-foot 2x6s, placed 3 feet on centers.

Supports, 3 rows 4x4s.

Joists, 2x10s, placed 3 feet on centers. Hemlock and yellow pine.

Floor, laid in eight directions.

Rafters, 2x6s spiked to studs. A band of two 1x6s is placed around the studs just below the rafters, and helps support the rafters.

Supports for roof. There are three purline plates. Two of these are supported by posts, the other by braces running out from the silo. The roof is straight from eaves to peak. The bracing is similar to that of barn No. 4.

Silo, 18 feet in diameter, 56 feet deep, 2 feet in ground. Capacity, 350 tons.

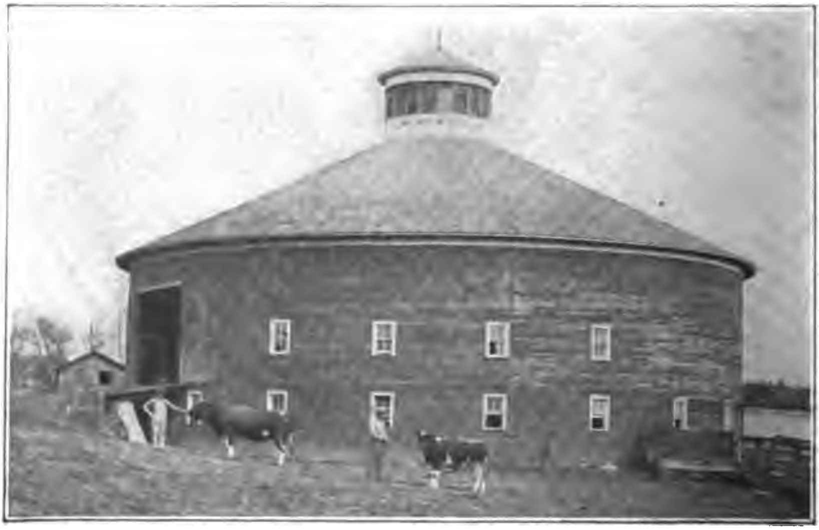

FIG. 34. BARN 92 FEET IN DIAMETER; TWO ROWS OF COWS HEADED TOGETHER; SILO IN CENTER.

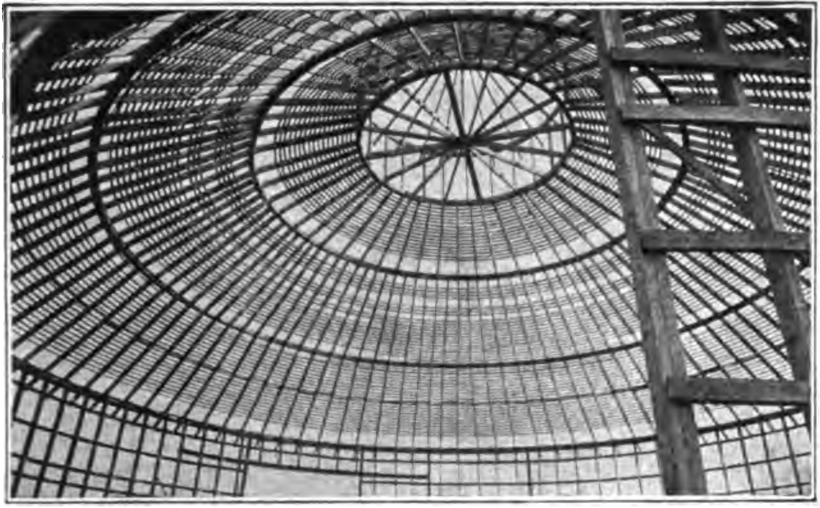

FIG. 35. VIEW OF 70-FOOT SELF SUPPORTING ROOF ON BARN SHOWN IN FIG. 36; NOTE HOOPS ON STUDS IN RIGHT FOREGROUND.

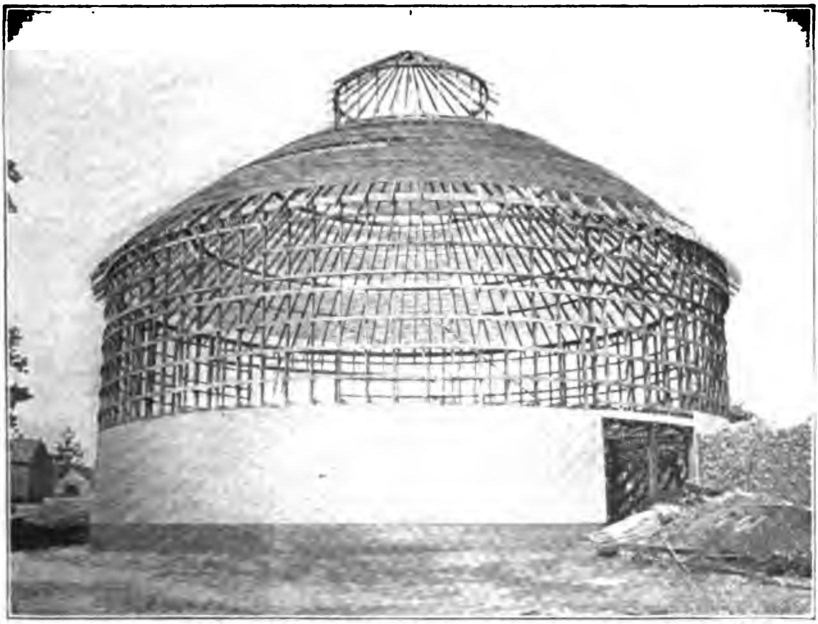

FIG. 36. BARN 70 FEET IN DIAMETER; FRAME HOOPED FOR PERPENDICULAR SIDING; LOWER SECTION SIDED.

THE SMALL DAIRYMAN'S BARN

The round barns previously described do not meet the needs of the man with only a few cows. He usually wants a general-purpose barn. The circular form can be made satisfactory for this

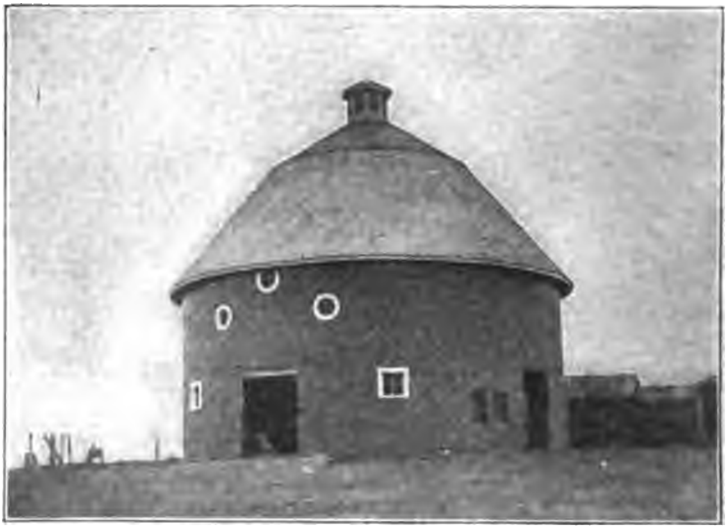

FIG. 37. BARN 40 FEET IN DIAMETER.

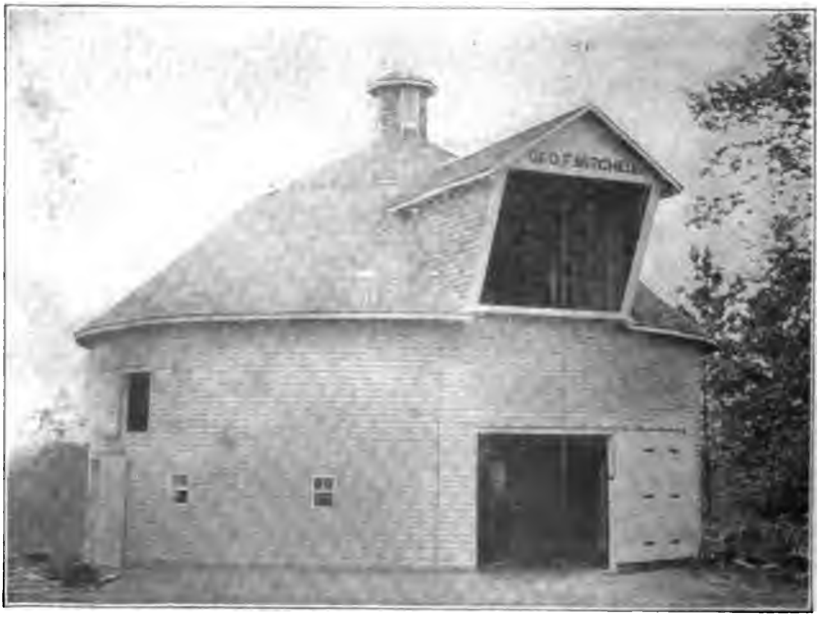

FIG. 38. BARN 48 FEET IN DIAMETER, 16-FOOT POSTS; NOTE METHOD OF TAKING HAY INTO SMALL ROUND BARN.

purpose if proper attention is given to the plan. It is necessary that the cow stable be distinctly separated from all other stock by a tight wall. Round barns with this arrangement are giving satisfaction in Illinois at the present time.

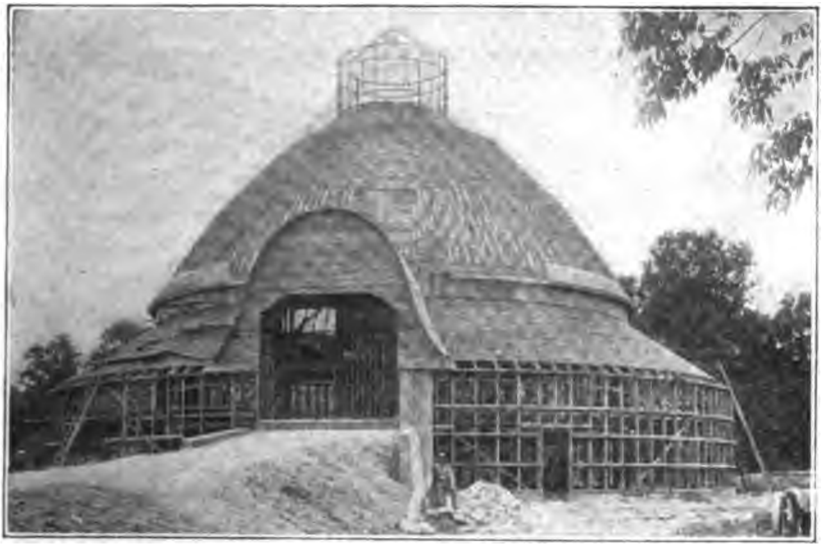

FIG. 39. SHOWING CONSTRUCTION OF BARN IN FIG. 40. HOOPS IN PLACE READY FOR PERPENDICULAR SIDING; ROOF SHEATHED FOR SHINGLES.

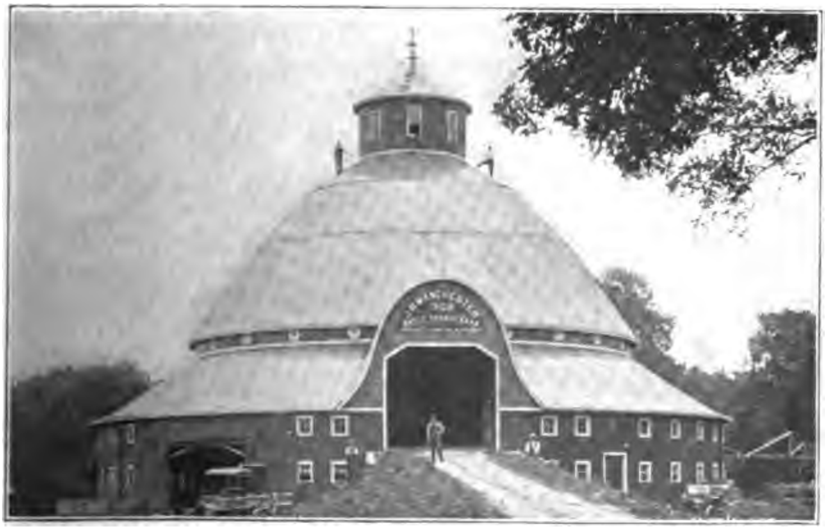

FIG. 40. BARN 102 FEET IN DIAMETER AND 85 FEET HIGH.

DISADVANTAGES OF THE POLYGONAL BARN

A polygonal barn has the disadvantages of both the rectangular and the round barn, and is less stable than either. It must necessarily have a heavy frame, which is expensive, and as the siding cannot run around the corners, it is very difficult to tie the different sides together sufficiently to prevent the barn being racked by the wind.

BARN NO. 6

16-sided.
Built, 1888.

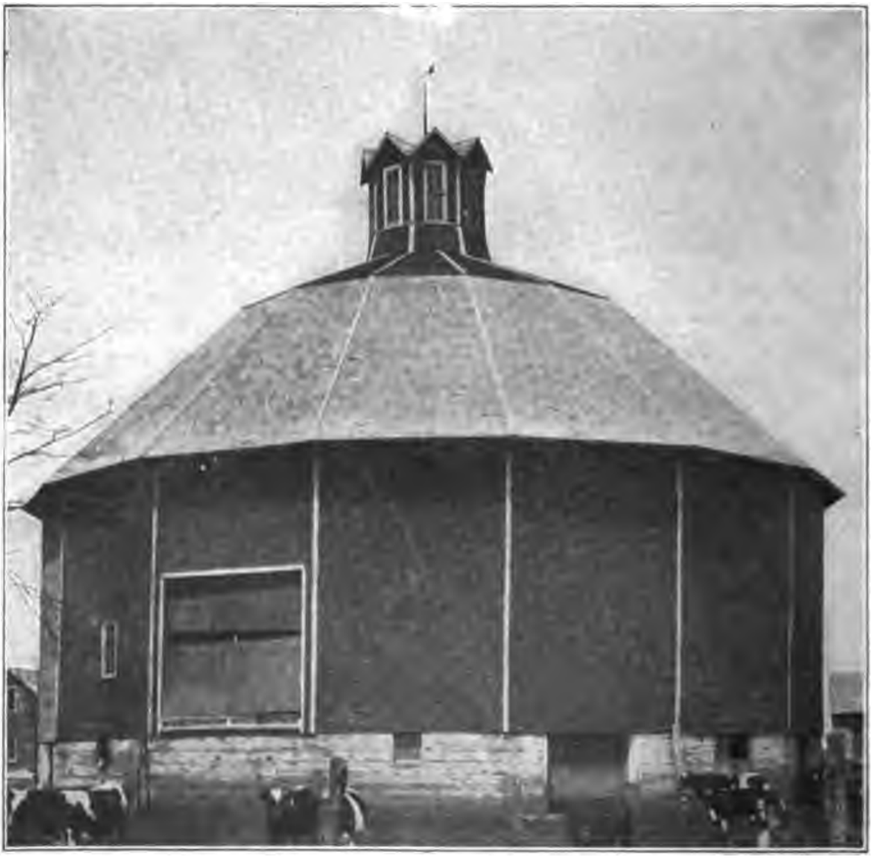

FIG. 41. BARN NO. 6; 85 FEET IN DIAMETER; SAME SCALE AS DRAWING ON OPPOSITE PAGE.

Diameter, 85 feet.

Height, 26-foot posts on 9-foot wall.

Capacity, 88 cows; 350 tons of hay.

Foundation and first story, cement wall 9 feet above cement floor.

Supports, 4x8s, placed just back of stanchions, 3 feet on center.

Studs, 2x10s, 26 feet long, placed 2½ feet on center.

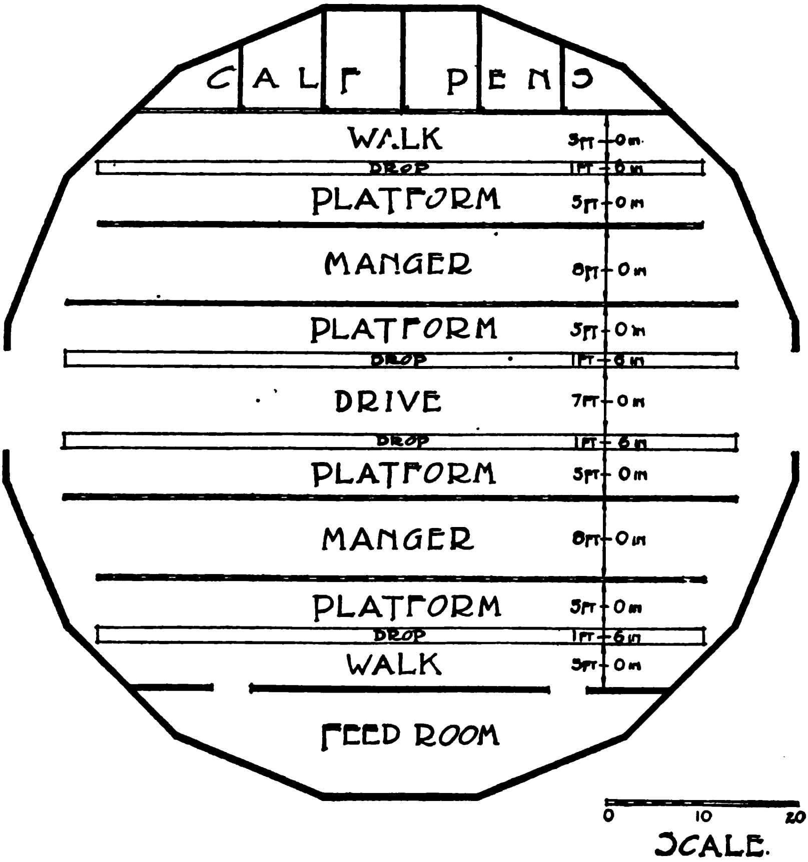

FIG. 42. ARRANGEMENT OF COW STABLE IN BARN NO. 6.

Joists 3x12s, 20 feet long, 14 inches on center for main span.

Rafters, self supporting. Sheathed with 1x6s with no space between. This roof has a purline plate thrown in the gambrel. The plate is supported only by the braces which tie the joints.

The barn has been racked three times by the wind, replumbed and heavy iron rods put in to brace it, yet it is out of plumb at the present time.

CONCLUSIONS

In summing up the data given in this bulletin, it is obvious that the advantages of the round barn are convenience, strength, and cheapness.

The round barn is the more convenient, because of the unobstructed mow, which reduces the labor required in mowing hay, and because of the greater ease and fewer steps with which the feed can be gotten to the cows, owing to the central location of the supply.

The circular construction is the strongest because advantage is taken of the lineal strength of the lumber. All exposed surfaces are circular, and withstand greater wind pressure, as the wind can get no direct hold, as on the sides or gable ends of a rectangular barn.

In round numbers, rectangular barns require, according to their construction, from 34 to 58 percent more in cost of material than round barns with the same floor area and built of the same grade of material.

4 41

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BULLETIN No. 144

GROWING TOMATOES FOR EARLY MARKET

By JOHN W. LLOYD AND I. S. BROOKS

URBANA, ILLINOIS, FEBRUARY, 1910

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SUMMARY OF BULLETIN NO. 144

1. Large, well grown plants are essential to the production of large yields of early tomatoes. Page 47

2. Fire hotbeds are extensively used in southern Illinois for the growing of tomato plants. Page 54

3. Manure hotbeds are more cheaply constructed than fire hotbeds, but are less reliable in cold weather. Page 57

4. For early tomatoes the seed is sown in February. Page 60

5. In March, the seedlings are shifted to another hotbed, where they are placed three inches apart. Page 61

6. After growing in the second hotbed three or four weeks, the plants are placed six inches apart in a cloth-covered coldframe. Page 62

7. Tomato plants must be carefully hardened off before they are set in the field. Page 63

8. The results of four years' fertilizer experiments in Union county indicate that for the production of early tomatoes in that vicinity, a mixture of steamed bone, dried blood and potassium sulfate is superior to the various other fertilizers tested. Page 65

9. The results of experiments in pruning and training indicate that pruning tomato plants to single stems reduces the yield of both early and late fruit, exposes the fruits to sunscald and cracking, and does not materially increase their size. However, staking tomatoes, without pruning, places the crop under the grower's control; and in the Union county experiments it increased the yield over that of untrained plants. Page 71

10. The results of five years' experiments in Union county show that the leaf spot of the tomato (Septoria lycopersici) can be controlled by spraying with Bordeaux mixture. Page 79

11. Tomatoes for shipment to distant markets should be picked before they are fully colored, but for local markets may be allowed to ripen on the vines. Page 83

12. Rigid grading of tomatoes is essential to successful marketing. Page 84

13. The standard package for tomatoes produced in southern Illinois is the four-basket crate. In the ideal pack each basket contains twelve tomatoes. Page 85

14. For the production of tomatoes acceptable to the trade, only smooth-fruited varieties should be grown. Page 87

GROWING TOMATOES FOR EARLY MARKET

By JOHN W. LLOYD, Assistant Chief in Olericulture, and
I. S. BROOKS, Assistant in Olericulture

Tomatoes are grown by nearly every market gardener and in some localities the shipment of tomatoes to distant markets is an important industry. Early tomatoes usually bring much higher prices than late, and it is the early crop for which most gardeners strive. Several factors have a bearing upon the successful production of early tomatoes, and it is the purpose of this publication to consider somewhat in detail the methods employed by commercial growers in the production of this important crop, together with the results of certain experiments conducted by the Illinois Agricultural Experiment Station.

INFLUENCE OF CHARACTER OF PLANTS UPON YIELD OF TOMATOES

The size and character of the plants at the time of transplanting to the field have a marked influence on the yield of early tomatoes. The age of the plants and the conditions under which they have been grown determine their size and character. Plants ten or even twelve weeks old, that have made a slow, steady growth, and have been provided with sufficient room so that they have remained stocky, and have retained all their lower leaves in a vigorous and healthy condition, are capable of giving quick results provided they can be transplanted to the field without seriously disturbing their root systems. However, an old plant that has begun to stretch for light or to lose its lower leaves, or to turn yellow because of outgrowing its allotted space, is inferior to a younger and smaller plant occupying the same space. Within reasonable limits, then, the size and age at which plants are to be set will be determined largely by the amount of space they can be allowed while growing, and the provisions which can be made for transplanting them without disturbing the roots.

In order to secure some definite data regarding the influence of the age and character of the plants upon their yield of early fruits, some tests were made at Urbana in 1908 and 1909. In 1908 different lots of plants were grown as follows:

1. Seed sown in flat in greenhouse March 1. Seedlings potted up in 2½-inch pots March 21, and shifted to 4-inch pots April 10. Pots transferred to coldframe April 14.
2. Seed sown in 2½-inch pots in greenhouse March 1. Seedlings thinned early to one in a pot, and shifted to 4-inch pots April 11. Pots transferred to coldframe April 14. Plants shifted to 6-inch pots May 5.
3. Seed sown in flat in greenhouse, March 1. Seedlings pricked out into other flats, 3"x3", March 21, and set in soil of coldframe 6"x6" April 14.
4. Seed sown in hotbed April 1. Seedlings shifted to coldframe 3"x3' April 20.
5. Seed sown in coldframe April 20. Plants set in field without previous shifting.

Ten plants from each lot were set in the field May 16, when the oldest plants were approximately eleven weeks old. A hot, dry wind was blowing at the time the planting was done, and the plants grown without pots suffered considerably in the transplanting, while the pot-grown plants did not wilt in the least.

These five lots of plants, grown under different conditions until time of setting in the field, but set in the field the same day and given identical treatment thereafter, afforded an excellent opportunity of testing the influence of the early treatment and age of the plants upon the resulting crop. The following tabular statement gives the date the earliest fruit ripened in each plat, the date when the various plats averaged one ripe fruit per plant, and the yield of early fruit in pounds per plant. In this connection, "early fruit" means all marketable fruit which ripened previous to August 11. Up to that date, all the tomatoes suitable for market were sold to Champaign and Urbana grocers for $2.25 per bushel. After that date, local tomatoes became abundant and the price dropped rapidly to 50c per bushel, and remained at approximately that figure the rest of the season.

TABLE 1.—YIELDS OF EARLY TOMATOES FROM PLANTS GROWN UNDER DIFFERENT CONDITIONS, 1908

Lot	Treatment	First ripe fruit	Date ave. one ripe fruit per plant	Lb. early fruit per plant
1	Seeded Mar. 1 in flat; shifted to 2½" and 4" pots.............	July 15	July 24	4.12
2	Seeded Mar 1 in 2½" pots; shifted to 4" and 6" pots...... ..	July 11	July 21	5.91
3	Seeded Mar. 1 in flat; shifted to other flat; then coldframe 6" x 6"........................	July 15	July 27	2.91
4	Seeded Apr. 1 in hotbed; shifted to coldframe 3" x 3".........	July 24	Aug. 5	1.65
5	Seeded Apr. 20 in coldframe; not shifted.....................	Aug. 10	Aug. 14	.25

These figures show that Lot 2 was plainly superior to all the others in every respect. How much of this superiority was due to the starting of the seeds in pots, so that the root systems of the plants were not disturbed in shifting as was the case with the seedlings started in the flat, and how much to the final shift to six-inch pots, was not determined. It is true, however, that the plants started in pots were larger at all stages of their development before setting in the field than those started in flats on the same date, and that after being set in the field they were the first to set fruit. The advantage of setting large plants of considerable age, is clearly shown by the markedly greater yields of early fruits from the plants started March 1 as compared with those started April 1 and 20.

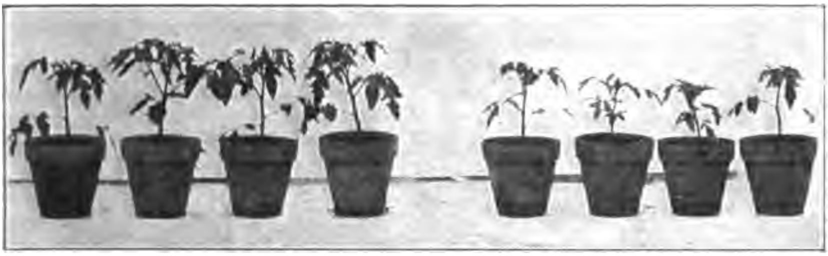

FIG. 1. TOMATO PLANTS AT LEFT FROM SEED SOWN IN POTS (LOT 2); AT RIGHT, FROM SEED SOWN IN FLAT, AND SEEDLINGS SHIFTED (LOT 1). APRIL 24, 1908.

That there is no advantage in retaining plants in the coldframe after the normal season for putting them in the field, even if they are given ample room in the frame, is illustrated by the performance of ten plants that were grown under the same conditions as those in Lot 1 up to the time the latter were set in the field, but were then shifted to 6-inch pots and held in the coldframe till June 1. These plants were in thrifty condition when placed in the field and suffered no apparent injury in the transplanting, but they were slow in coming into bearing, not ripening their first fruit until July 17, and producing only 1.79 lb. of fruit per plant before August 11.

In 1909, further tests were made, the first seed being sown earlier than in 1908, with a view to having large, well-developed plants ready for setting out at the earliest date the weather would permit. The various lots of plants were grown as follows:

1. Seed sown in flat in greenhouse February 13. Seedlings potted up in 3-inch pots March 13, shifted to 4-inch pots April 3, and to 6-inch pots April 19. Pots transferred to coldframe April 19. Plants set in field May 4. At the time of setting in the field these plants were large and well developed and not in the least pot-bound. A few were in bloom.
2. Grown the same as lot No. 1, but held in the coldframe until May 15, when they were set in the field. At the time of setting, these plants were rather tall and the foliage was lighter in color than it should have been owing to the long time the plants had been held in the coldframe. These plants were 13 weeks old when set in the field.
3. Seed sown in flat in greenhouse February 27. Seedlings potted up in 2½-inch pots March 23, shifted to 4-inch pots April 12 and to 6-inch pots April 24. Pots transferred to coldframe April 24. When set in the field, May 15, these plants were in ideal condition, being 8 to 10 inches tall and extremely stocky, with dark green foliage all the way to the bottom. Blossom buds were visible on every plant, but no blooms were open. Roots could be seen next to the pot but the plants were not in the least pot-bound.
4. Seeds sown in 2½-inch pots in greenhouse February 27. Seedlings thinned early to one in a pot, and shifted to 4-inch pots April 12; shifted to 6-inch pots April 24. Pots transferred to coldframe April 24. Set in field May 15. These plants did not make a good growth in the 2½-inch pots and were still small even when shifted to the 6-inch pots. The slow growth of these plants was directly opposite to the performance of those similarly grown in 1908, and was probably due to some difference in the soil used in the 2½-inch pots. Altho small when set in the field, as compared with plants of Lot 3, these plants were short, stocky and of good color.
5. Seed sown in flat in greenhouse February 27. Seedlings pricked out into another flat 3"x3", March 23. Plants set in soil of coldframe 4"x5", April 22. Set in field May 15. These plants were rather tall when placed in the coldframe and did not make a very satisfactory growth there. They should have been allowed more space. They were too tall and the foliage was rather light colored when they were set in the field.
6. Seed sown in flat in greenhouse February 27. Seedlings potted up in 2½-inch pots March 23, and shifted to 4-inch pots April 12. Pots transferred to coldframe April 24. Set in field May 15. These plants were treated the same as those of Lot 3 except that the final shift to 6-inch pots was omitted. When set in the field, they had begun to stretch for light, and were about 14 inches tall. The lower foliage was yellow and the roots were pot-bound.
7. Seed sown in flat in greenhouse March 27. Seedlings pricked out into another flat, 3"x3", April 16. Flat transferred to coldframe April 24. When set in the field, May 15, these plants were rather small, that is, about six inches tall, but were stocky and in good healthy condition. They were planted with the dirt adhering to the roots, and did not wilt in the least.
8. Seed sown in flat in greenhouse April 17. Flat transferred to coldframe as soon as seedlings were up. Plants set in field May 15 without previous shifting. They were at this time about three inches tall, and were just putting out the first pair of true leaves. Since they were set without dirt adhering to the roots, they wilted badly, even tho care was taken to prevent undue exposure during the planting. They were the only plant which wilted after being set in the field.

All plants were given identical treatment after being set in the field, except for the tillage received by the plants set May 4 before the others were transplanted. Any differences in earliness and yield, then, must have been due to differences in the plants caused by differences in age and methods of handling. The following tabular statement shows the date of ripening of the earliest fruit from each lot, the date at which each lot averaged one ripe fruit per plant, the yield of marketable fruit before August 1, and the yield up to August 12. The reason for making this division of the yield of early fruits is that up to August 1, the price of tomatoes on the local market was $2.40 per bushel, while from August 1 to 12 it averaged $1.40 per bushel. After that the price dropped to 60c, and did not reach above 80c at any time later in the season.

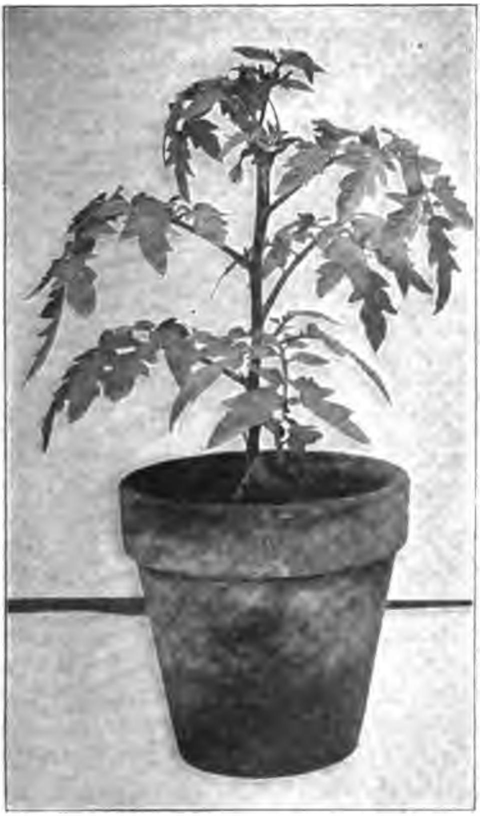

FIG. 2. TOMATO PLANT IN IDEAL CONDITION FOR SETTING IN FIELD. FROM LOT 1, AS SET, MAY 4, 1909.

TABLE 2.—YIELDS OF EARLY TOMATOES FROM PLANTS GROWN UNDER DIFFERENT CONDITIONS, 1909

Lot	Treatment	First ripe fruit	Date Ave one ripe fruit per plant	Lb. per plant	
				Before Aug. 1	To Aug. 12
1	Seeded Feb. 13; shifted to 3", 4" and 6" pots. Set May 4....	July 13	July 21	3.73	9.89
2	Seeded Feb. 13; shifted to 3", 4" and 6" pots. Set May 15 ...	July 13	July 17	2.05	6.41
3	Seeded Feb. 27; shifted to 2½", 4" and 6" pots. Set May 15	July 10	July 19	2.52	7.20
4	Seeded Feb. 27 in 2½" pots; shifted to 4" and 6" pots. Set May 15.................	July 15	July 23	2.50	7.46
5	Seeded Feb 27 in flat; shifted to other flat. then coldframe. Set May 15..	July 15	July 19	1.46	5.34
6	Seeded Feb. 27 in flat; shifted to 2½" and 4" pots. Set May 15	July 15	July 21	2.22	5.69
7	Seeded Mar. 27; shifted to 3" x 3". Set May 15..................	July 23	July 30	.96	5.37
8	Seeded Apr. 17. Not shifted. Set May 15...........	Aug. 7	Aug. 11	0.00	.79

This table shows that the early plants set May 4 did not ripen their first fruit any earlier than some of the other lots, but that they made by far the heaviest yield of early fruit. These plants were set before the normal season for planting tomatoes in this locality, and before it was really safe to set them, for altho the weather was warm and pleasant at the time they were set, a frost occurred a week later and caused slight injury to the plants. However, favorable weather followed, and the plants were evidently not seriously checked in their development. That holding the plants in the coldframe after they have reached the fullest development consistent with their allotted space seriously interferes with their production of early tomatoes is well shown by the record of Lot 2 as compared with Lot 1. This same point is further illustrated by the showing of Lot 6, held in 4-inch pots, as compared with Lot 3, in which plants of the same age had been shifted to 6-inch pots, so that they were not checked in their development previous to setting in the field. A comparison of Lots 2 and 3 also shows that the younger plants produced the better results by reason of being unchecked in growth previous to setting. Altho the plants of Lot 4, grown from seed sown directly in pots, were much smaller than those of Lot 6 at the time of setting in the field, and were a few days later in ripening their earliest fruits, the yield of fruit before August 1 was approximately the same and the yield up to August 12 was greater for the plants started in pots. In fact, this lot produced the highest yield of early fruit of any of the lots set in the field on the same date. This corroborates the results obtained in 1908, tho the differences are not so striking.

The plants shifted from the flat to the soil of the coldframe (Lot 5) were no later in ripening their first fruit than two of the lots of pot-grown plants of the same age, but the yield before August 1 was considerably less. However, they had produced quite a satisfactory crop by August 12. As already explained, these plants did not grow very well in the coldframe, on account of being allowed to become too tall before being shifted to the frame and not being given sufficient room. Plants properly grown in the coldframe, and handled as carefully as these were in the transplanting to the field would probably have made a better showing. It is interesting to note that plants grown from seed planted a month later than this lot were only eight days later in ripening

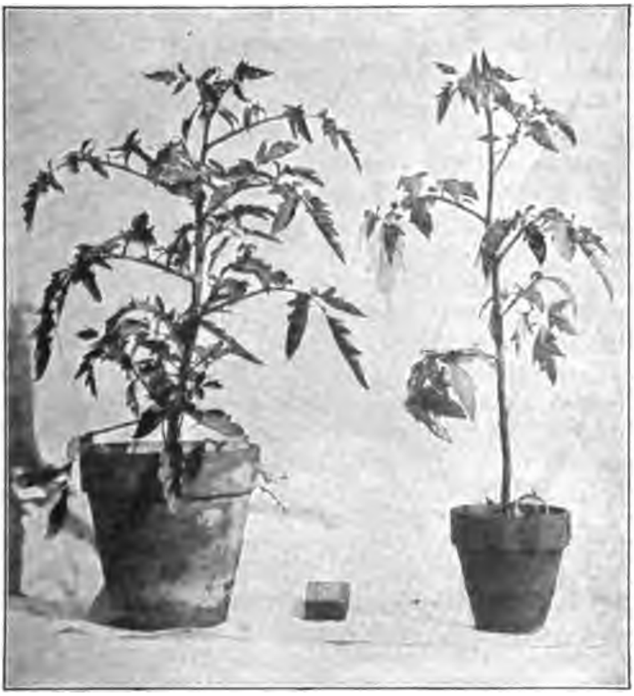

Fig. 3. Tomato plants of same age, in six-inch and four-inch pots, from Lots 3 and 6 respectively.

the first fruit, and by August 12 had produced a slightly greater yield. The plants of this last lot (No. 7) were in excellent condition when set in the field, so that altho small and young, their more thrifty condition enabled them to overtake the older plants. This is another illustration of the fact that the condition of the plant may be more important than its age.

That the differences in the plants at the time of setting in the field influence chiefly the yields of early fruit and have comparatively little influence on the later yields is well illustrated by the performance later in the season of the plants under consideration. In 1908, the plants in the different lots, which had yielded all the way from .25 lb. to 5.91 lb. of early fruit per plant, produced very nearly the same amount of late fruit per plant, the lowest yield of late fruit being 8.51 lb. per plant and the highest, 9.66 lb. In 1909 the differences in yield of late fruit were somewhat greater, the yields varying from 7.77 lb. to 11.01 lb. per plant. Plants that had produced a heavy crop of early fruit continued to produce abundantly until killed by frost. Also plants that had produced only a light early crop on account of securing a late start, likewise produced heavily late in the season. This indicates that, as grown on the black prairie soils of Central Illinois, the tomato plant is capable of continuing in bearing until killed by frost, regardless of the time it begins. The production of a heavy crop early in the season does not impair its vigor enough to seriously affect the yield of late fruits. This means that all the extra early fruits a tomato plant can be made to produce are practically clear gain.

HOTBEDS

While the ideal method of growing tomato plants involves starting the seed in a greenhouse late in winter, most growers have not the advantage of greenhouse facilities, and are therefore obliged to resort to the use of hotbeds. These are of two types: the fire, and the manure, hotbed. The former type is better adapted to starting the plants in cold weather, but either type will answer for receiving the plants at the first shift.

CONSTRUCTION OF FIRE HOTBEDS

The essential features of a fire hotbed are a long sash-covered frame underlaid by two flues connected with a fire-pit at one end and chimneys at the other. An ideal location for the hotbed is a gradual slope to the south or east. Such a location insures full exposure to sunlight, protection from cold winds, good draft for the flues and drainage for the fire-pit. An area six feet wide and from 80 to 100 feet long is marked off in such a way that one end of the bed will be a few feet higher than the other. A row of posts is set along each side of this area, those on the north or west side extending 18 inches above the level of the ground and those on the south or east side 12 inches. These posts must be set about 2½ feet deep to prevent their being heaved out by frost. The distance between the posts will depend upon the length of lumber to be used in making the frame. For 16-foot lumber, the posts should be placed 5 feet 4 inches apart.

After the posts are set, boards are nailed onto the inside of these rows of posts to make the walls of the bed. It is well to allow the boards to extend two inches above the tops of the posts, so that the latter will not interfere with the sash.

The dirt should be dug out from between the walls to within three inches of the posts on either side. At the upper end of the bed, it is dug out to a depth of six inches, the depth gradually increasing until the lower end of the bed is reached, where it is 2½ feet. The excavation is extended several feet beyond the lower end of the bed. This extension is made one foot narrower and 1½ feet deeper than the bed proper. Six feet of the upper part is to be used for the fire-pit, the lower part being dug out for convenience in firing. The sides of the pit are walled up with rock or brick to a height of two feet and covered with broad flat rocks well supported by iron bars, or the cover may be entirely of old boiler iron.

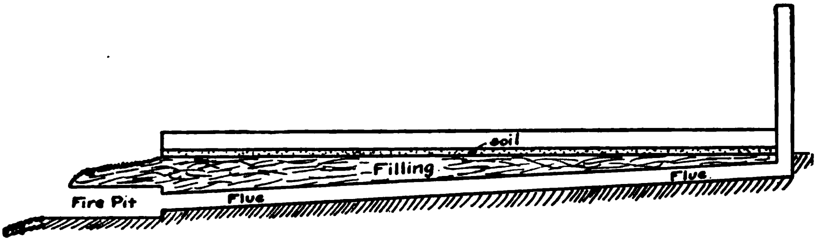

FIG. 4. LONGITUDINAL SECTION OF FIRE HOTBED.

From each side of the back of the fire-pit, a trench twelve inches deep and nine inches wide is dug diagonally toward the side of the bed. When within four inches of the side of the excavation the direction is changed and the trench cut parallel with the side of the bed. These trenches are covered closely with flat stones to prevent dirt from filling them. The dirt which is first filled in over these stones is well packed to prevent smoke from going thru into the dirt of the bed. Thus, flues are made which conduct the heat and smoke under the bed to the chimneys at the upper end.

In localities where rock is not easily obtained, sewer tile 4 to 6 inches in diameter are sometimes used for flues in place of the rock-covered flues above described. In this case, it is unnecessary to excavate the full width of the bed, since the tile can be placed in the bottom of trenches dug to the proper depth.

Chimneys for the upper ends of the flues are made by nailing together four ten-inch boards. The board on the side toward the flue should be a foot shorter than the other three so as to allow an opening into the chimney.

As the flues are finished, most of the dirt which was dug out is shoveled back into the bed, filling it to the original level or perhaps two inches higher. Boards are nailed across the ends of the bed. The fire-pit is covered about two feet deep and the remainder of the dirt is banked against the outside of the walls of the bed. Additional dirt should be piled against the walls to bank them to the top, for the severe weather of February and March will make it necessary to protect the plants as much as possible.

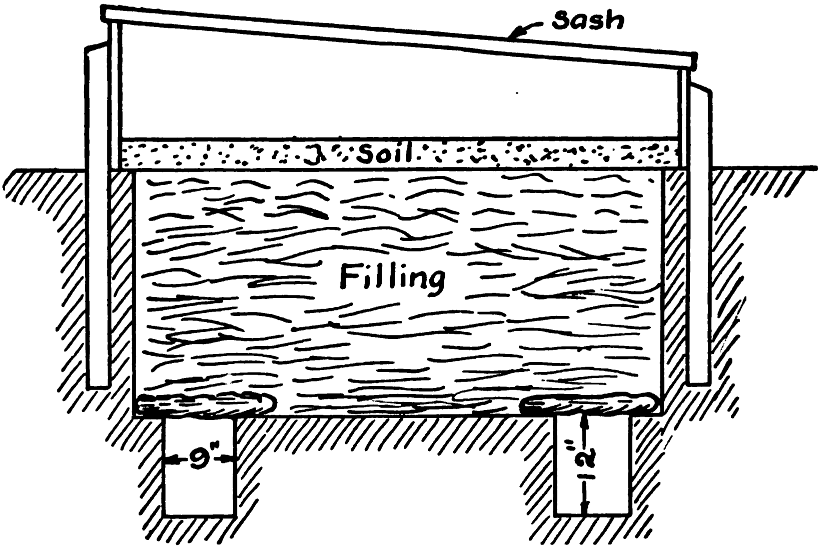

FIG. 5. CROSS-SECTION OF FIRE HOTBED.

To be in readiness for use in the spring the bed should be completed in the fall, and the soil put in for growing the plants. This should be about four inches deep. Soil rich in humus and relatively free from weed seeds is secured. This is usually enriched with well-rotted manure in the proportion of one load of manure to ten loads of soil. After the soil is put in, the bed is left open to the weather until late in December, when it is covered with sash to keep out rain and snow.

The sash are supported by cross-bars resting on the walls of the bed. Each cross-bar is made by nailing together two strips of wood, one of which is 1"x3" and just long enough to fit loosely between the walls of the bed, and the other is 1"x2" and as long as the sash, so that the ends may rest upon the sides of the bed. These supporting strips afford a base on which to slide the sash in opening the bed, and also insure good connections between adjoining sash.

Early in February, about a week before the seeds are to be planted, a fire is started in the pit in order to warm the soil in the bed and put it in condition for working. A hot fire is required for several days to get the bed into good condition at this time of the year, but after the soil has once become warm much less fuel is needed to keep up sufficient heat.

CONSTRUCTION OF MANURE HOTBEDS

When only a small number of plants is wanted, it is usually preferable to grow them in a manure hotbed, rather than go to the labor and expense of constructing a fire hotbed. A manure hotbed may be made very cheaply by placing a sash-covered frame on top of a flat pile of fermenting manure. However, such a bed is badly exposed to winds, and is less satisfactory in cold weather than a bed made by placing the frame above a pit containing the manure. The pit may be merely an excavation in the ground or may be walled up with plank or even brick, if a permanent bed is desired. The bed must be in a well drained location if the manure is placed in a pit; otherwise water would likely seep into the pit and interfere with the proper fermentation of the manure.

The preparation of manure for a hotbed should begin at least three weeks before the hotbed is to be used. Fresh horse manure from grain-fed animals should be placed in a compact pile. The manure should contain a fair amount of litter but should not be too strawy. If it is rather dry, it should be moistened with water as it is being piled. As soon as fermentation has become well started, the manure should be thoroly forked over and re-piled. Care should be taken to break up all lumps and place the coolest manure from the outside of the original pile in the midst of the new pile, to insure uniform fermentation of the entire mass. As soon as the whole pile is steaming, the manure may be placed in the pit, or in a flat pile eight feet wide if the bed is to be constructed entirely above ground. The manure should be thoroly tramped as it is being piled, and care taken to have it uniformly compact thruout the bed, so that it will not settle unevenly and let the soil sink away in spots after the bed is in operation. A good plan is to put the manure on in layers about six inches deep, and tramp each layer thoroly before putting on the next. When the bed is completed, the manure should be about two feet deep. If a pit has been used, the manure should extend approximately to the level of the ground.

As soon as the manure has been placed in the bed, the frame and sash should be put on to protect the bed from rain or snow and help retain the heat. The soil in which the plants are to be grown may be placed in the bed at this time or a few days later, but in no case should seeds be sown or plants set until after the violent heat following the moving of the manure has somewhat subsided. Sometimes this violent heating does not become evident for three, four, or even more, days after the bed is made, and a person is inclined to think the bed is not going to heat. It would be a serious mistake to plant the bed at this juncture, for if the manure is of good quality and has been properly handled, the violent heating is sure to occur, and would kill any seeds or plants in the bed. Some persons favor putting in the soil wnen the bed is first made, for the sake of killing the weed seed in the soil by this violent heating. After the bed has heated up, and then cooled down to 85° F. the tomato seeds may safely be sown.

The hotbed frame should be twelve inches high in front and sixteen or eighteen inches high at the rear. It should be six feet wide, outside measure, and long enough to accommodate the number of sash required; or if a large amount of hotbed space is required, it is a common practice to make a series of beds of four sash each. Since a "3x6" sash is a little over three feet wide, the frame will need to be over twelve feet long to accommodate four sash. It is a good plan to measure the exact width of the four sash to be used, and cut the lumber for the frame accordingly. In making the back of the frame avoid having a crack near the top of the bed. If only a small amount of hotbed room is needed, a bed may be made with only two, or even one, sash. Unless the hotbed is of the permanent type, it is advisable to have the frame put together with screws, so that it may be taken down at the close of the season without splitting the lumber. The frame can then be stored in a small space until needed the next season. The accompanying diagram shows the arrangement of the different parts of such a frame made for two sash, together with enlarged views of the corners and joints.

With a hotbed frame made as indicated there will be room for four inches of soil in which to grow the plants, and still leave eight inches of space between the soil and sash at the front of the bed. A cross-section of a hotbed of the simplest and cheapest type, showing the location of manure, soil, and sash, is shown in Fig 7.

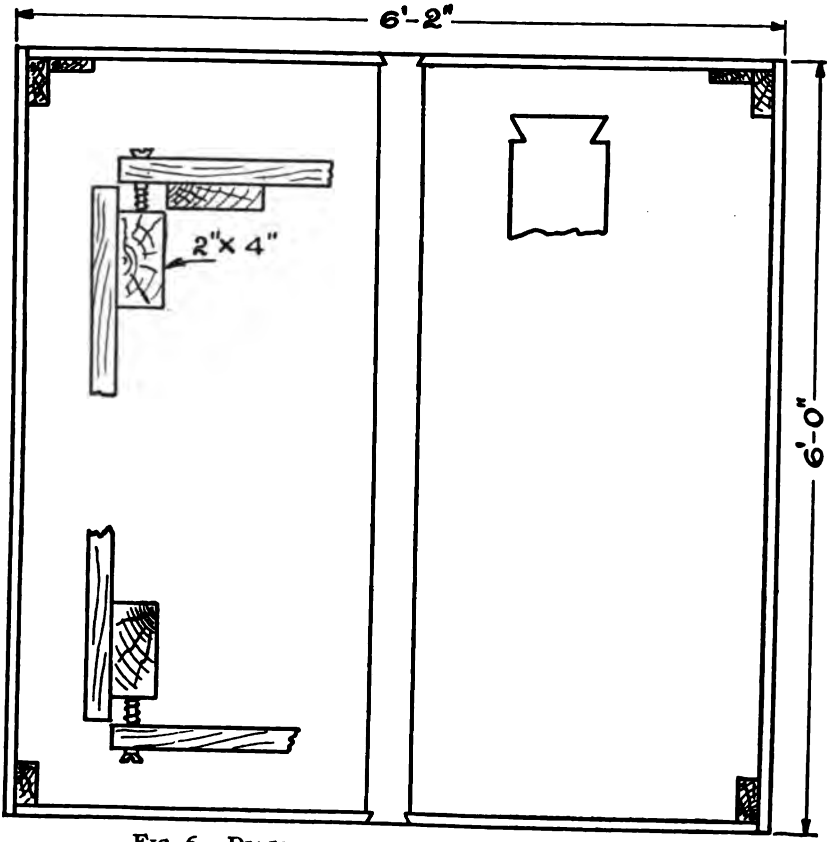

FIG. 6. DIAGRAM OF FRAME FOR MANURE HOTBED.

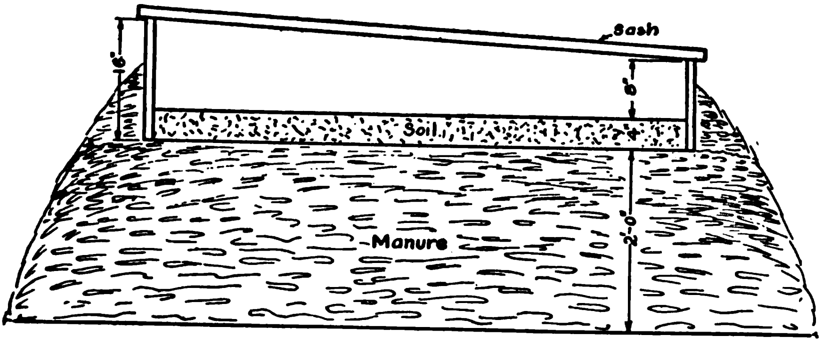

FIG. 7. CROSS-SECTION OF MANURE HOTBED.

PLANTING THE SEED

The method of preparing the soil in the bed and planting the seed is the same whether a fire hotbed or a manure hotbed is used. When the proper temperature has been secured, the soil is leveled off and worked down into a fine seed-bed. The time of planting the tomato seed will depend somewhat upon the latitude. In the extreme southern part of the state, the seed is sown from February 10 to 20. Farther north the planting is done from March 1 to 15. About four seeds to the inch are sown in rows three or four inches apart. Sown at these distances one ounce of seed will plant a little over two sash. One ounce of seed is usually planted for each acre of tomatoes to be set in the field, tho this allows for considerable loss and the rejection of all inferior plants.

CARE OF THE HOTBED

After the seeds have been planted, the hotbed should be closed, and a thermometer placed in each end. A temperature of as near 65° F. as possible should be maintained, tho no damage is done if for a short time the temperature becomes as low as 50° F. or as high as 90° F.

The plants come up about a week after the planting of the seed, and are allowed to grow in the seed-bed for two or three weeks, or until the second rough leaf appears. Usually no watering is necessary during this time, but the ground between the rows should be stirred once a week.

Fresh air must be let into the bed every day. This is done by sliding or slightly raising the sash. If the weather will permit, the bed is left slightly open for several hours in the middle of the day. When the weather is so cold and windy that the bed cannot be left open for any length of time it is opened a little for a few minutes two or three times during the day. The plants must not be chilled; still they should have all the air it is possible to give them, in order to prevent them from damping off and to make them grow stocky.

When the weather becomes unusually cold the plants must have more protection than is afforded by the glass. The moisture which collects on the under side of the glass should never be allowed to freeze. If freezing should occur the subsequent melting of the ice would cause ice-cold water to drip on the plants. Additional protection may be provided by spreading over the glass one or two thicknesses of canvass or several inches of straw. This additional covering should be removed as soon as practicable, for keeping out the light makes the plants grow long and slender.

In moderate weather sufficient heat can be kept in a fire hotbed if the firing is attended to at regular intervals three times a day. At times of severe weather, however, twice as much attention must be given to firing as when the weather is moderate. Wood is the fuel most commonly used, tho some fire-pits are equipped with a rude grate so that coal can be burned when wood is not available.

SHIFTING THE SEEDLINGS

When the plants are about three weeks old they must be shifted to give them more room. They are usually placed three inches apart each way, in another hotbed. This bed must be covered and the proper temperature secured before it is needed for the plants. In taking up the plants from the seed-bed, a flat stick or a trowel is used to lift them out, so as to avoid injury to the roots. The rows for resetting may be marked off by using a broad board an inch shorter than the bed is wide, to one side of which ¼-inch square strips have been nailed three inches apart each way. The side of the board on which the strips are nailed is placed upon the soil at the end of the bed, is pressed down firmly, then lifted back to where the next marks are to be made, and is used for the operator to stand upon while setting plants in the marks previously made.

The plants are usually set with a dibber or sharpened stick, and are placed into the ground up to the seed leaves. In shifting the small tender plants it is very important that care be taken to avoid injuring them by rough handling.

This first shifting of the plants is done early in March, so that severe weather often hinders the progress of the work, for plants must not be exposed to cold when taken from a warm hotbed. Sometimes a sort of tent is placed over the part of the bed to be set, when it is necessary to do the work in unfavorable weather.

The plants grown under one sash in the seed-bed will reset at least four sash, when only the largest, strongest plants are used.

After the plants are set, the management of the beds as to ventilation is essentially the same as for the seed-bed except that as the weather becomes warmer the plants should be exposed more and more. The heat of a manure hotbed will gradually subside and that of a fire hotbed should be gradually diminished. Toward the end of the period that the hotbed is needed, the fire is often allowed to die out entirely during the day, tho a small fire may be necessary at night. A little later the fire is discontinued entirely, so that the soil temperature will be normal before the plants are removed from the hotbed to the coldframe.

As soon as possible after the plants have been removed from the hotbed. 2"x4" pieces should be nailed between the walls crosswise of the bed, at intervals of six feet, in order to prevent the walls from warping, so that the sash will fit the next season. The ends of the flues should also be stopped, to keep out rabbits and ground-hogs.

COLDFRAMES

Coldframes are frequently located permanently near the hotbeds. They are also built temporarily along the edge of the field in which the plants are to be set, or put near the middle of the field, then torn down and removed as soon as the plants have been taken out.

CONSTRUCTION OF COLDFRAMES

The construction of a coldframe is similar to that of a hotbed in some respects. The same width is desirable, but the frame may be any length. The walls are made the same except that the posts do not need to be set so deeply, and the back wall is a foot higher than the front. There is no digging to be done and no flues nor furnace to be built. In winter, stable manure is spread upon the strip where the coldframe is to be built, a load of manure to three rods. Early in spring a strip 5½ feet wide is plowed three or four times to mix the manure and earth, and is left in a ridge until needed for planting. The walls for the coldframe are put up along this ridge whenever time and weather permit. The outside of the walls are banked with earth by digging a trench around the coldframe. This also insures good drainage.

One inch below the top on the inside of the walls, blocks of wood 1"x2"x4" are nailed at intervals of 4 feet. These are to support the ends of cross-bars of 1"x2" stuff cut long enough to fit tightly crosswise of the bed between the walls for supporting the cover. For making the cover two widths of heavy, unbleached muslin are sewed together. One edge of this cover is nailed to the top of the upper wall, while the other edge is fastened to a roller made by nailing together two 1"x2" strips of wood in such a way that the strips break joints and form a continuous roller as long as the bed, except in the case of unusually long beds, when the cover is made in sections for convenience in handling. The cover must be of such a width that when put over the coldframe the roller comes a little beyond the top of the lower wall. The weight of the roller then holds the cover in place.

SHIFTING PLANTS TO THE COLDFRAME

After the plants have been in the second hotbed for three or four weeks they are ready to be shifted into the coldframe. They should be shifted before they grow so large as to become crowded.

The soil of the coldframe is worked down into good condition and the plants set at distances of 6"x6". This gives sufficient room for growth until time for setting into the field. Set at these distances in the coldframe the plants for setting an acre in the field will require a coldframe about 90 feet long.

MANAGEMENT OF COLDFRAMES

By the time the plants are set in the coldframe, the season has advanced sufficiently to permit the frame to be left entirely open a large part of each day. However, there are frequently days when the plants must be kept protected from cold winds, and nights when even additional covering must be supplied. On warm windy days the cover may be kept open at the ends of the bed in order to admit air freely and still protect the plants from mechanical injury by the wind. The grower should be very cautious about leaving the cover off at night, for a sudden change in temperature, which is common at that season of the year, might do irreparable damage. When there is danger of a freeze, straw should be placed on the cover to a depth of 4 or 5 inches. Another cover is often placed on top of the straw. The plants will probably need some watering while in the coldframe, but only enough to prevent wilting and to keep them growing.

HARDENING-OFF THE PLANTS

Tomato plants that have been grown under the protection of a hotbed and coldframe are likely to suffer severely when transplanted to the field unless they have been gradually inured to outside conditions. To prepare the plants for withstanding the transfer to the field without suffering a sudden check in growth, they must be gradually accustomed to winds and night temperatures while they are still in the coldframe. Beginning about two weeks before the time for setting the plants in the field the frame is left uncovered later each evening and is adjusted so as to let in a little air even at night. Finally on pleasant nights the cover is left off entirely. The plants should be thus exposed for several nights before they are set in the field. This treatment causes them to make a slow, woody growth, so that they do not wilt badly when transplanted. It also prepares them to stand the ordinary night temperature in the field at the normal season for transplanting.

TRANSPLANTING TO THE FIELD

In Southern Illinois a few tomato plants are usually set in the field the latter part of April, but these nearly always suffer more or less from cold weather early in May, and it is often a great deal of trouble to prevent their being killed by frost. About May 10 is the earliest date at which it is safe to set tomatoes even in Southern Illinois. The plants are at that time ten to twelve weeks old, and should be 8 to 10 inches high, with a stem somewhat larger than a lead pencil, and covered with dark green foliage. Flower buds will be numerous and some blossoms will probably be open.

The plants are usually set 4 by 5 feet apart, or 4½ by 4½ feet. At the first distance named, 2,178 plants are required to set an acre, and at the latter distance, 2,151 are required. Dwarf varieties may be set closer.

In preparing a field for tomatoes, the land is plowed early in the spring, and worked occasionally until time for planting. Immediately before planting it is thoroly pulverized and furrowed out for the reception of the plants. Furrows are first made crosswise the field, with a one-horse turning plow or a single-shovel plow. Then when everything is in readiness to start the planting, the furrows are made in the other direction only as fast as needed, so that the plants may be set in freshly turned soil. If the plants are to be fertilized in the hill, the application is made at this time.

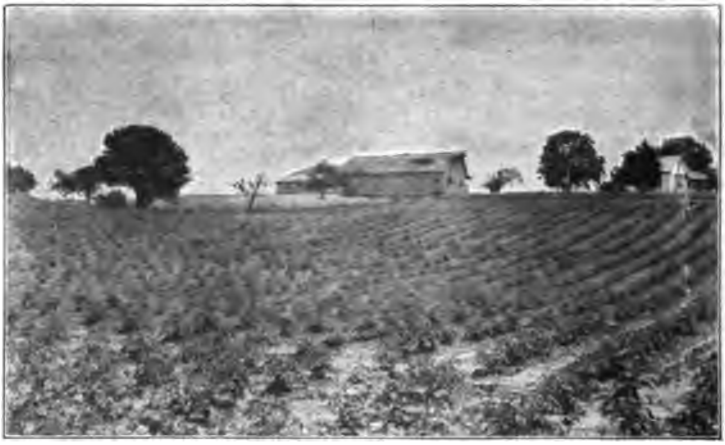

FIG. 8. FIELD OF EARLY TOMATOES, UNION COUNTY, ILLINOIS.

A few hours before the planting is to begin, the soil in the coldframe containing the plants should be saturated with water and should be kept wet as the planting proceeds.

The plants are removed from the coldframe by cutting around each plant with a spade, then pushing the spade under the cube of dirt containing the plant, and lifting it onto a wagon. Thus a six-inch cube of dirt is taken up with each plant. The spade is unloaded by resting it upon the wagon and pushing the cube of dirt off with the hands. A low wagon with a long platform is very convenient for this work. Bolster springs are also of value at this time to lessen the jolting which tends to shake the dirt from the roots of the plants.

The plants are hauled to the field on the wagon and from it they are lifted by hand and placed in the furrows. Dirt is hilled up about the plants with hoes, that which is first drawn in being well firmed. The plants should be set deep enough to stand erect, and should be cultivated immediately after setting.

FERTILIZING

In addition to being large and healthy at the time of setting in the field, a tomato plant must be well supplied with plant food if it is to produce an abundant crop of early fruits. Some soils are rich enough to produce a good crop without the addition of fertilizing materials, but many soils on which tomatoes are grown commercially require the addition of plant food. Various materials are used and are applied sometimes broadcast and sometimes in the hill. For the purpose of securing information regarding the influence of different fertilizers and methods of application upon the yield of early tomatoes in Southern Illinois, experiments have been conducted in Union county the past four years.

The soil upon which the experiments were made was the typical clay soil of the region. Commercial growers in that locality do not attempt to grow tomatoes without adding fertilizer of some kind before setting the plants.

Plats consisting of 20 plants each (except in 1906, when there were 40 plants in each plat) were treated as follows:

Plat 14. Commercial fertilizer in hills
15. Manure in hills
16. Manure and steamed bone in hills
17. Manure and rock phosphate in hills
18. Check. No fertilizer or manure
19. Steamed bone in hills
20. Home-mixed fertilizer in hills
21. "Castoria" in hills
22. "Castoria" in hills, air-slaked lime broadcast
23. Home-mixed fertilizer broadcast
24. Manure broadcast
25. Manure and steamed bone broadcast
26. Manure and rock phosphate broadcast.

The commercial fertilizer applied to Plat 14, known locally as "Phosphate," was the brand of fertilizer used by most of the tomato growers of that locality. The guaranteed analysis of this fertilizer was: Nitrogen, 1.64%; Phosphoric acid (available), 3.49%; Potassium, 5.81%. The same kind of manure was used both broadcast and in the hills, and in all cases was fairly well rotted. The "Castoria" applied to Plats 21 and 22 was castor bean pomace, a by-product of castor oil mills. The home-mixed fertilizer applied to Plats 20 and 23 consisted of 2 parts dried blood, 2 parts steamed bone meal and 1 part potassium sulfate.

With the exception of the manure, each material was used at the same rate whether applied broadcast or in the hills. In 1906, the commercial fertilizer, steamed bone, rock phosphate and home-mixed fertilizer were used at the rate of ¼ pound per plant, or 10 pounds per plat. The "Castoria" was used at double this rate, or ½ pound per plant. Fifty pounds of lime were used on Plat 22. Where manure was applied to the hills, about one-fourth scoop-shovelful was put in each hill. This amounted to a little over three tons per acre. The manure applied broadcast was used at the rate of about ten tons per acre, whether used alone or in combination with other materials.

In 1907, the various materials were applied at the same rate per plant as in 1906. In 1908, the quantities of all materials except the manure were doubled, but in 1909 they were again used at the same rate as in 1906 and 1907, with the exception of the lime which was used at the same rate as in 1908. The quantity of manure applied broadcast was reduced in 1909 to an amount equal to that applied in the hills.

The tests were made in a different field each year, on soil that had not recently been fertilized, so that there was no cumulative effect of the fertilizers as might have been the case if the tests had been made on the same plot of ground year after year. So far as these experiments are concerned, the effect of the fertilizers upon crop yields could appear only the year the applications were made, for the same land was not used twice during the experiments. This is in accordance with the usual method of fertilizing for truck crops. The fertilizer is applied for its benefit to the crop that one season, rather than for its ultimate effect upon the fertility of the land.

Each year, all plats were treated alike in reference to tillage and other care, so that any differences in yield or earliness would be attributable to differences in fertilizer treatment. The fruit was picked from three to four times per week, as is the practice in gathering the crop for shipment. Careful records were kept regarding the number and weight of fruits from each plat at each picking. The fruit was also sorted into marketable and unmarketable grades. The different fertilizer treatments did not materially influence the size or grade of the fruits. The yield and earliness, however, were influenced to considerable extent.

INFLUENCE OF FERTILIZER UPON EARLINESS OF RIPENING

The date when the first tomatoes were picked varied with the earliness or lateness of the season, from June 24 to July 10. About two weeks after picking begins there is usually a sudden drop in prices, for the price depends largely upon the supply. The yield of marketable tomatoes up to the time of this drop may be considered as the true index of the earliness of the crop. The yields during this period for each season, are given in Table 3. For the sake of uniformity, the yields are expressed in terms of pounds per plant.

TABLE 3.—YIELDS OF EARLY TOMATOES IN POUNDS OF MARKETABLE FRUIT PER PLANT

Plat	Treatment	1906	1907	1908	1909	Average
14	Commercial fertilizer in hills.........	.49	1.35	1.30	.33	.86
15	Manure in hills........................	.27	1.50	.68	.27	.68
16	Manure and bone in hills.............	.30	2.75	1.53	.22	1.20
17	Manure and rock phosphate in hills ..	.46	1.54	.73	.26	.74
18	Check. No fertilizer.................	.18	1.70	.34	.39	.65
19	Bone in hills..........................	.26	2.09	1.63	.67	1.16
20	Home-mixed fertilizer in hills........	.45	2.24	1.70	.66	1.26
21	"Castoria" in hills.	.18	1.78	1.36	.56	.97
22	"Castoria" in hills, lime broadcast....	.36	2.14	1.10	.48	1.02
23	Home-mixed fertilizer broadcast......	.95	2.20	2.25	.60	1.50
24	Manure broadcast.....................	.12	1.93	.43	.46	.73
25	Manure and bone broadcast	.26	1.93	1.48	.43	1.02
26	Manure and rock phosphate broadcast	.15	1.75	1.35	.35	.90

These figures show that the highest average yield of this extra early fruit was produced by the home-mixed fertilizer applied broadcast, and that the second highest average yield was produced by the same material used in the hills. Manure used alone either broadcast or in the hills produced but slightly better results on the average than were secured where no treatment whatever was given. However, where steamed bone was used with the manure, the average yields were much better. Used alone in the hills, the bone gave almost as good results as the combination of bone and manure in the hills, and better results than this material applied broadcast. "Castoria" in the hills with lime applied broadcast, gave the same average yield as manure and bone broadcast. The commercial fertilizer commonly used in the locality did not produce nearly so good average yields of these extra early tomatoes as did the home-mixed fertilizer, or the bone either alone or in combination with manure.

INFLUENCE OF FERTILIZER UPON TOTAL YIELD OF MARKETABLE TOMATOES

The yields for the entire shipping season are given in Table 4. In most cases these yields do not represent the actual total yields of the plants, for under normal conditions the plants continue bearing long after the close of the shipping season. The shipping season for tomatoes in Southern Illinois is determined by market conditions rather than the condition of the plants, so that altho the figures given below do not represent the actual yields, they do represent the total yields from a commercial standpoint. Only tomatoes suitable for shipment, produced during the normal shipping season, are considered in this table. Again the yields are expressed in terms of pounds per plant.

TABLE 4.—TOTAL YIELDS OF MARKETABLE TOMATOES IN POUNDS PER PLANT

Plat	Treatment	1906	1907	1908	1909	Average
14	Commercial fertilizer in hills	2.27	4.95	3.71	2.62	3.38
15	Manure in hills	2.40	4.24	3.71	1.75	3.02
16	Manure and bone in hills	1.08	6.43	3.72	1.87	3.27
17	Manure and rock phosphate in hills	3.20	4.94	3.83	1.63	3.40
18	Check. No fertilizer	.50	5.16	3.32	1.77	2.68
19	Bone in hills	.64	5.82	3.46	2.84	3.19
20	Home-mixed fertilizer in hills	2.63	6.11	4.10	2.79	3.90
21	"Castoria" in hills	2.92	5.81	3.67	2.39	3.69
22	"Castoria" in hills and lime broadcast	1.84	6.47	4.25	2.89	3.86
23	Home-mixed fertilizer broadcast	1.86	6.55	4.24	2.67	3.83
24	Manure broadcast	1.00	6.15	3.79	1.70	3.16
25	Manure and bone broadcast	1.12	5.70	5.38	1.89	3.52
26	Manure and rock phosphate broadcast	1.10	6.49	5.68	1.63	3.72

These figures show that in average total yield of marketable tomatoes all the fertilizer treatments showed a decided increase over the yield of the check plat which received no fertilizer, even though in some years some of the treatments seemed to decrease the yield. The home-mixed fertilizer applied to the hills produced the highest average yield, and the yield from the same material applied broadcast was only slightly less. The only other treatment that gave an average yield as good as either of these was "Castoria" in the hills in conjunction with lime applied broadcast. The benefit of the lime was shown by the greater yield from this treatment than from the use of "Castoria" alone. Whether or not lime would have had a similar effect if used in connection with the other fertilizers was not determined.

It is worthy of special notice that some of the fertilizer treatments which did not produce good yields of extra early fruits gave relatively high total yields during the shipping season. This is true of the manure and rock phosphate, especially when applied broadcast, tho when used in the hills it also made a much better showing for the whole season than for the early part of the season. On the other hand, the influence of the bone, whether used alone or with manure, was much less marked on total yields than on early yields.

In regard to the influence of the method of application of the fertilizer upon the yields, there seems to be no uniformity from year to year. However, if the average yields are considered, the results seem to indicate an advantage in favor of the broadcast applications, tho it is true that in the case of manure alone or in combination, larger quantities were used broadcast than in the hills, except the last year, so that the increase may have been due to the difference in quantity rather than the difference in method of application. This interpretation of the results is supported by the fact that when equal quantities were used (in 1909) the yields were practically the same for both methods of application. With the home-mixed fertilizer, the same quantities were used in both methods of application thruout the experiment, and there was little difference in the average total yields, tho the broadcast application gave decidedly the better average early yields. This striking difference in average early yields is due quite largely to the marked difference in yields the year large quantities of the fertilizer were used.

The poorest average yield for any of the fertilizer treatments was produced by the manure applied to the hills, and the next poorest by the same material applied broadcast. Thus the manure gave the poorest results in reference to both early yields and total yields. This indicates that, under the conditions of these experiments, the application of manure alone, immediately before planting tomatoes, is not conducive to the production of early or large yields, and suggests that if manure is employed for tomatoes it might better be applied to the preceding crop. On other soils the results might be entirely different, and it is true that enormous yields of tomatoes are sometimes produced on rich garden soils that have been heavily manured every year thru a series of years.

On the whole, it may be said that, under the conditions of these experiments, the home-mixed fertilizer seems most capable of producing consistent yields of both early and late fruits, and that, so far as yields are concerned, there seems to be little choice between the two methods of applying this material, except where excessive quantities are to be used. In this case, broadcasting would be preferable to applying the fertilizer in the hills. The convenience of making the application should also be considered. If fertilizer is applied to the hills, the work must be done by hand, after the land is furrowed out and before the plants are set. The fertilizer is usually scattered over about a square foot of space in the bottom of the furrow, and the block of soil containing the plant is placed in immediate contact with the fertilizer. In making broadcast applications, the material may be applied either by hand or with a drill, and then mixed with the soil by the disking and harrowing employed preparatory to furrowing out the land for the reception of the plants.

In the above discussion regarding the relative merits of the different fertilizer treatments, only absolute yields have been considered, and no reference has been made to the relative cost of the increased yields due to the use of the different fertilizers. For the sake of comparing the different treatments on this basis, Table 5 is introduced. In this table, all figures are given on the acre basis, and represent the averages for the four years. The average increase in yield for each plat over the yield of the check plat is given in column 1. These yields are expressed in crates per acre. Column 2 gives the average cost of each fertilizer treatment per acre. Column 3 gives the average cost per crate of increase, and is derived by dividing the cost of the fertilizer treatment per acre by the number of crates increase. The figures in column 4 represent the relative net profits per acre from the use of the fertilizer. For the sake of this comparison, an arbitrary value of 40 cents per crate for the tomatoes has been assumed. This figure was chosen because it is an approximate average price for early tomatoes from Southern Illinois, but any other price could have been used and the net profits would have stood in the same relation to each other. The figures in column 4 were derived by subtracting the cost per crate of increase from the value per crate and multiplying the remainder (which represents the profit per crate) by the number of crates increase. The figures in this last column, then, represent the profit from the use of the fertilizer—not the net profit from the entire crop, for the average yield from the check plat was 326 crates per acre, and the figures given in column 1 represent the number of crates increase over the yield of the check plat due to the fertilizer treatment.

TABLE 5.—PROFITS PER ACRE, DUE TO THE USE OF FERTILIZER

Plat	Treatment	Ave. number of crates increase over check	Average cost of fertilizer	Average cost per crate increase	Net profit
14	Commercial fertilizer in hills	74	$ 8.91	$ .120	$20.72
15	Manure in hills	30	5.51	.183	6.51
16	Manure and bone in hills.............	72	15.50	.215	13.32
17	Manure and rock phosphate in hills...	89	8.31	.093	27.32
18	Check. No fertilizer................	0	0	0	0
19	Bone in hills.........................	48	9.98	.208	9.22
20	Home-mixed fertilizer in hills...	139	15.76	.113	39.89
21	"Castoria" in hills	114	14.26	.125	31.35
22	"Castoria" in hills and lime broadcast	136	35.65	.262	18.77
23	Home-mixed fertilizer broadcast......	133	15.76	.118	37.51
24	Manure broadcast	58	12.45	.214	10.79
25	Manure and bone broadcast...........	94	24.93	.265	12.69
26	Manure and rock phosphate broadcast	122	15.30	.125	33.55

Column 4 in the above table gives a comparison of the profits based not only on the increase in yield but also on the cost of the increase. Some treatments which gave comparatively small increase did so at such a small cost per crate that the net profits rank fairly well. Such a result is illustrated by Plat 17. Other treatments gave a large increase, but at such an expense per crate that the net profits are comparatively low. A marked example of such a treatment is shown by Plat 22. The treatments applied to Plats 21 and 26, respectively, gave large increases at a moderate cost per crate, and so gave good net returns. The treatments applied to Plats 20 and 23 gave even greater yields than Plats 21 and 26, and at a lower cost per unit of increase. Thus, the net profits as shown in column 4 are markedly above those for any other treatment. The initial cost of the fertilizer given Plats 20 and 23 as shown in column 2, was more than that for most of the other treatments. Nevertheless the net profits, which are the real basis for comparison, show clearly that the home-mixed fertilizer was the most profitable treatment used.

PRUNING AND TRAINING

Experiments in the pruning and training of tomatoes have been conducted in Union county and also at Urbana. In Union county the conditions under which these tests were made were the same as for the fertilizer experiments excepting that all the plats in the pruning and training experiment were fertilized alike. At Urbana the plants were grown without the use of fertilizer of any kind. The different methods of pruning and training employed were as follows:

Plat 7. Pruned to single stems and topped after setting three clusters of fruit
8. Pruned to single stems; not topped
9. Pruned to single stems early in the season, then allowed to branch
10. Pruned to two stems
11. Pruned to three stems
12. Tied to stakes, but not pruned
13. Neither staked nor pruned.

In the pruning, the branches to be removed were cut close to the main stem, care being taken to avoid injuring the leaf below the branch. The branches were removed while small. The training consisted in tying the plants to stakes. All plats except No. 13 were treated alike in this respect. A stake 1½ to 2 inches square and about five feet long was driven into the ground close to each plant. To this the plant was tied with soft twine. The first tying was done when the plants were about 18 inches high and before they fell over of their own weight. Three tyings in a season were usually sufficient to keep the plants properly supported, tho sometimes four tyings were necessary.

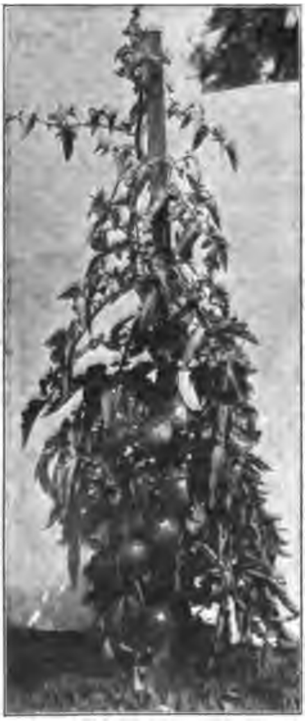

Fig. 9. Tomato plant pruned to a single stem.

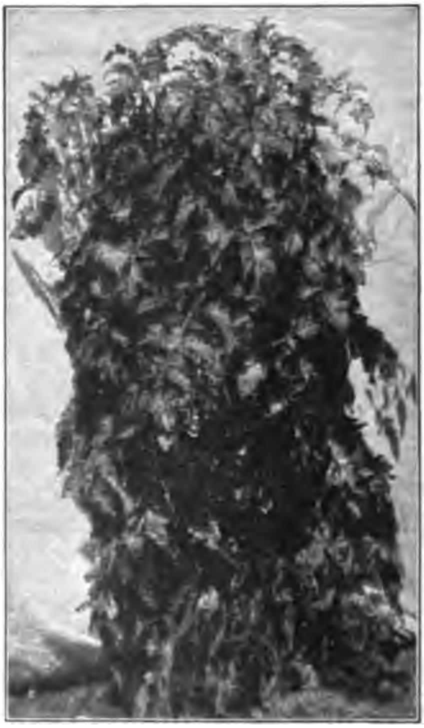

Fig. 10. Tomato plant supported by a single stake.

Influence of Pruning upon Earliness of Ripening

The date of ripening of the first specimen of marketable fruit on each plat for each season is given in Table 6 for the Union county experiment and in Table 7 for the tests at Urbana.

Table 6.—Date of Ripening of First Marketable Tomato from Each Plat, Union County

Plat	Treatment	1906	1907	1908	1909
7	Pruned to single stem; topped......	July 7	July 13	July 4	June 24
8	Pruned to single stem; not topped...	" 7	" 13	" 8	" 28
9	Pruned to single stem early; then branched	" 7	" 13	" 8	" 28
10	Pruned to two stems................	" 7	" 20	" 4	" 26
11	Pruned to three stems..............	" 7	" 10	" 8	" 30
12	Staked but not pruned..............	" 7	" 10	" 4	" 26
13	Neither staked nor pruned	" 18	" 17	" 8	" 26

TABLE 7.—DATE OF RIPENING OF FIRST MARKETABLE TOMATO FROM EACH PLAT, URBANA

Plat	Treatment	1907	1908	1909
7	Pruned to single stem; topped............	July 30	July 21	June 28
8	Pruned to single stem; not topped........	“ 30	“ 11	July 2
9	Pruned to single stem early; then branched	Aug. 8	“ 11	“ 10
10	Pruned to two stems	“ 2	“ 11	“ 13
11	Pruned to three stems....................	“ 2	“ 11	“ 10
12	Staked but not pruned....................	July 30	“ 15	“ 15
13	Neither staked nor pruned................	“ 27	“ 15	“ 15

These tables show that the plants pruned to single stems sometimes ripened their first specimen earlier than the unpruned plants, but that in other cases the reverse was true. In general there was no uniform relation between the severity of the pruning and the date of ripening of the earliest fruit.

A truer basis of comparison between the different plats is that already used in comparing the different plats in the fertilizer experiment; namely, the amount of early fruit produced while prices were high. The yields of early tomatoes determined on this basis are given in the following tables:

TABLE 8.—YIELDS OF EARLY TOMATOES IN POUNDS MARKETABLE FRUIT PER PLANT, UNION COUNTY

Plat	Treatment	1906	1907	1908	1909	Average
7	Pruned to single stem; topped	.64	.66	.65	.41	.59
8	Pruned to single stem; not topped...	.63	1.00	.70	.38	.67
9	Pruned to single stem early; then branched........................	.69	.99	.64	.59	.72
10	Pruned to two stems	.90	.73	1.34	.40	.84
11	Pruned to three stems	.50	1.73	1.13	.56	.98
12	Staked but not pruned...............	.49	1.50	1.33	.41	.94
13	Neither staked nor pruned.......	.07	1.31	1.29	.33	.79

TABLE 9.—YIELDS OF EARLY TOMATOES IN POUNDS MARKETABLE FRUIT PER PLANT, URBANA

Plat	Treatment	1907	1908	1909	Average
7	Pruned to single stem; topped.	.93	2.20	2.53	1.88
8	Pruned to single stem; not topped.... ...	1.26	2.02	2.85	2.04
9	Pruned to single stem early; then branched	1.05	2.72	5.10	2.95
10	Pruned to two stems....	1.22	3.85	5.07	3.38
11	Pruned to three stems	1.37	4.63	5.80	3.93
12	Staked but not pruned	1.19	4.75	8.51	4.81
13	Neither staked nor pruned.........	1.30	5.75	8.36	5.13

These tables show that in every instance the plants pruned to single stems produced low yields of early tomatoes, and that, on the average, these yields were much lower than those from plants less severely pruned or left unpruned. In Union county the plants pruned to three stems gave slightly higher yields, on the average, than those not pruned. At Urbana, however, the plants not pruned, showed a decided increase in average yield over all others. Another difference in the yields of early tomatoes, also apparently due to differences in local conditions, was that in every instance the plants which were staked but not pruned yielded in Union county more than those not staked, while at Urbana, the unstaked plants gave the higher average yields.

EFFECT OF PRUNING AND TRAINING ON TOTAL YIELD OF MARKETABLE FRUIT

When the total yields of marketable fruit are considered, the differences due to different treatment in reference to pruning and training are even more marked than when only the early fruit was considered. The yields for the Union county experiment are given in Table 10, and include only salable tomatoes which ripened before the close of the shipping season, since these represent the entire product which could be marketed.

TABLE 10.—TOTAL YIELDS OF MARKETABLE TOMATOES IN POUNDS PER PLANT, UNION COUNTY

Plat	Treatment	1906	1907	1908	1909	Average
7	Pruned to single stem; topped........	1.20	1.10	1.14	.88	1.08
8	Pruned to single stem; not topped ..	1.95	2.49	1.78	1.08	1.82
9	Pruned to single stem early; then branched.........................	3.20	3.84	2.87	1.50	2.85
10	Pruned to two stems...	2.26	1.90	3.66	1.45	2.31
11	Pruned to three stems................	1.07	3.16	3.58	2.06	2.46
12	Staked but not pruned	2.27	4.47	4.58	2.20	3.38
13	Neither staked nor pruned	.94	4.05	3.00	2.20	2.62

The total yields at Urbana are given in Table 11. These yields include all salable tomatoes which ripened before frost. The late fruit was in demand at fair prices on the local market. In addition to producing a good crop of early fruits, the plants remained healthy and continued to bear heavily during the early autumn. Thus the yields were much greater than those obtained during the shipping season in the southern part of the state.

TABLE 11.—TOTAL YIELDS OF MARKETABLE TOMATOES IN POUNDS PER PLANT, URBANA

Plat	Treatment	1907	1908	1909	Average
7	Pruned to single stem; topped	4.52	4.66	3.21	4.13
8	Pruned to single stem; not topped	7.79	5.56	6.28	6.54
9	Pruned to single stem early; then branched	11.63	13.42	15.87	13.64
10	Pruned to two stems	12.43	9.63	9.47	10.51
11	Pruned to three stems	13.60	10.32	12.51	12.14
12	Staked but not pruned	14.34	16.08	19.06	16.49
13	Neither staked nor pruned	16.12	21.57	21.32	19.67

These tables show that the plants pruned to single stems were comparatively low in total yields, as they were in early yields. In general the pruning reduced the total yields somewhat in proportion to its severity. Special attention should be called to the plants pruned early to single stems and then allowed to branch. The plants were pruned only once or twice and soon outgrew the effects of the early pruning so that at the end of the season they had practically as many branches as the unpruned plants, and ranked well in total yield.

The tables show further that the plants which were staked but not pruned gave in Union county, larger yields than those which were allowed to grow naturally upon the ground, while at Urbana the results were the reverse. These results correspond to those in reference to early yields already noted, and demand explanation. It will be remembered that the yields reported in the tables represent only the marketable fruit. In Union county the proportion of the crop which could be graded as marketable was much greater for the plants which were staked but not pruned than for those which were not staked; while at Urbana the proportion of marketable fruits was approximately the same for plants under both treatments. This is plainly shown by Table 12.

TABLE 12.—PERCENTAGE OF MARKETABLE TOMATOES

Plat	Place	Treatment	1906	1907	1908	1909	Average
12	Union Co.	Staked but not pruned	55.60	46.55	77.69	35.55	53.84
13	"	Neither staked nor pruned	39.80	30.23	61.45	35.24	41.68
12	Urbana	Staked but not pruned		71.70	73.10	69.89	71.56
13	"	Neither staked nor pruned		70.38	76.50	68.86	71.91

The cause of the greater percentage of culls on the unstaked plants in Union county was the rotting of the fruit in contact with the ground in wet weather, and the injury by sunburning of the fruits unprotected by the foliage in hot weather. An untrained plant affords much less protection to its fruits from the sun than does a trained plant. At Urbana, there was much less injury from both these causes than in Union county, owing to the differences in rainfall and intensity of heat. This at least partially accounts for the differences in results of these treatments at the two places.

EFFECT OF PRUNING ON SIZE OF TOMATOES

Pruning is often recommended as a means of increasing the size of tomatoes, and single stem pruning urged especially for the production of large fruits early in the season. For the purpose of securing data regarding the effect of pruning upon the size of the fruits the tomatoes from the plants in the pruning experiment in 1907, 1908 and 1909, were counted as well as weighed, so that the average weight of the specimens from each plat could be determined. The average weights of the fruits classed as early tomatoes from the various plats, are given in Tables 13 and 14. In calculating these averages, all fruits, both marketable fruits and culls, have been included. The weights are expressed in pounds.

TABLE 13.—AVERAGE WEIGHT OF EARLY TOMATOES PER FRUIT, UNION COUNTY

Plat	Treatment	1907	1908	1909	Average
7	Pruned to single stem; topped	.235	.291	.273	.266
8	Pruned to single stem; not topped	.270	.306	.284	.286
9	Pruned to single stem early; then branched	.265	.332	.303	.300
10	Pruned to two stems	.281	.335	.288	.301
11	Pruned to three stems	.281	.329	.269	.293
12	Staked but not pruned	.226	.337	.255	.272
13	Neither staked nor pruned	.195	.303	.279	.259

TABLE 14.—AVERAGE WEIGHT OF EARLY TOMATOES PER FRUIT, URBANA

Plat	Treatment	1907	1908	1909	Average
7	Pruned to single stem; topped	.451	.410	.382	.414
8	Pruned to single stem; not topped	.438	.418	.363	.406
9	Pruned to single stem early; then branched	.414	.434	.376	.408
10	Pruned to two stems	.444	.372	.382	.402
11	Pruned to three stems	.380	.418	.435	.411
12	Staked but not pruned	.359	.432	.348	.379
13	Neither staked nor pruned	.394	.410	.399	.401

The average weights of the early fruits are used for this comparison rather than the average weights for the total crop, because the most severely pruned plants produced only lightly after the ripening of the early fruits, and it seemed advisable to compare the size of fruits produced at the same time.

In both localities the pruning had but slight effect upon the size of the fruit and in only one case did the plants pruned to single stems produce the largest fruits. Pruning to single stems not only failed to increase the size of the early fruits, but also reduced the foliage to such an extent that the fruit was badly exposed. Sunburning and cracking of the fruit followed. The excessive cracking of fruits on single stem plants, especially those which were topped, was one of the most striking features of the experiment.

Since pruning to single stems reduces the yield of both early and late fruit, exposes the fruits to sunscald and cracking, and does not materially increase their size, it is not to be recommended. Less severe pruning, tho less detrimental to the plants, and in some cases apparently increasing the yield over that of unpruned plants, does not give results warranting its practice. The pruning of tomatoes adds considerably to the expense of their culture, and under the conditions of the experiments reported, such expense is unwarranted.

Whether or not tomatoes should be staked and tied, or allowed to lie naturally upon the ground, seems to depend upon local conditions. In localities where tomatoes are subject to rot and sun-

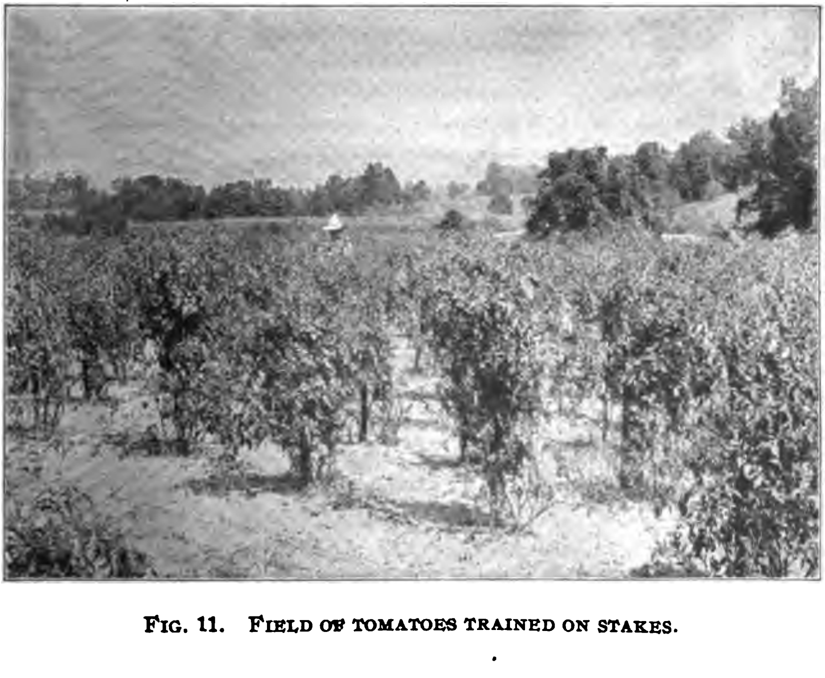

FIG. 11. FIELD OF TOMATOES TRAINED ON STAKES.

scald it is a decided advantage to have them upon stakes. Also where the season is likely to be dry, the tomato crop is under better control if trained on stakes, for cultivation can then be continued as late as desired. This would be impossible with untrained plants, for they fall to the ground from the weight of their fruit. The fruit from trained plants is also held up from the ground so that it is not spattered with mud in times of rain, and therefore requires less wiping in preparation for market. Under the conditions existing in Union county, it would seem advisable to practice staking and tying, while at Urbana the crop seems to succeed fully as well without training. However, in exceptionally wet seasons, staking might be an advantage even in localities where conditions are similar to those at Urbana.

Another factor which should be considered is the difference in cost of training tomatoes in different localities. The cost is considerably greater in a prairie region like that in the vicinity of Urbana, where the stakes must be purchased at the lumber yard, than in regions where native timber is abundant.

SPRAYING FOR THE CONTROL OF LEAF SPOT

While the tomato is subject to attack by several fungous diseases, the one most prevalent and widely distributed in this state is the leaf spot (*Septoria lycopersici*) often called the "rust." This disease is especially destructive in the southern part of the state. Its presence may be recognized by the appearance of small, circular, brown spots upon the lower leaves. The infection gradually progresses upward on the plant, the leaves dying in the order of their infection, as the season advances. In cases of severe attack, the leaves die more rapidly than new foliage is formed, and the plants become so weakened that they cease to produce marketable fruit. On untrained plants bereft of their lower leaves the fruit is very likely to sunburn.

On account of the prevalence of this disease and its economic importance to commercial growers in Southern Illinois, experiments were undertaken in Union county to determine the value of spraying as a means of control. These experiments have been continued for five successive seasons. In all the spraying the standard 4-4-50 Bordeaux mixture was the material used. When tomato worms appeared, Paris green was added to the mixture. Each year, the various plats in the experiment were sprayed as follows:

Plat 1. Sprayed at intervals of two weeks thruout the season, beginning after the plants were set and continuing until the shipping season was over
2. Sprayed every two weeks until the shipping season began

3. Sprayed every four weeks thruout the season
4. Sprayed every two weeks until the plants were staked
5. Sprayed every two weeks, beginning after the plants became badly infected with leaf spot, and continuing until the close of the shipping season
6. Check. Not sprayed.

METHOD OF SPRAYING

The spraying was done with a barrel hand pump and double vermorel nozzle. Some seasons the plats were arranged in a long narrow strip so that a wagon could be driven along each side and the spraying done with the aid of a long hose and bamboo pole. To do spraying in this way on a commercial scale it would be necessary to leave driveways thru the field every sixty or seventy feet. To spray without having these driveways, the spray barrel may be mounted on a low, one-horse cart with an axle short enough to go between two adjoining rows of tomatoes. Such a cart was used for the experimental work in 1905 and 1906. With this arrangement ten or fifteen feet of hose are sufficient and a short spray pole is more convenient than a long one. This method of spraying is adapted only to staked tomatoes, while the other may be employed for tomatoes either staked or unstaked. In both methods two men are required to do the work, one to drive and pump and the other to hold the nozzle.

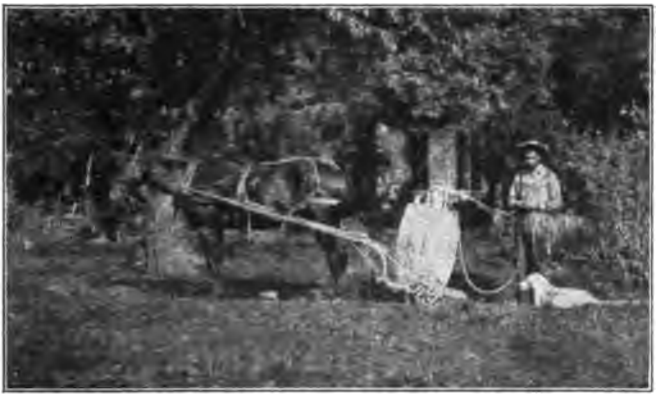

FIG. 12. SPRAY CART USED IN SPRAYING TOMATOES.

The date of the first application varied in the different seasons from May 16 to June 12. Usually the disease had appeared in the plantation before the first application was made, and in 1908 the infection was so bad that treatment to Plat 5 was begun at the time of the second application to Plat 1. In other years the infection did not become bad until somewhat later. The number of applications given each plat each year is shown in Table 15.

TABLE 15.—NUMBER OF APPLICATIONS OF SPRAYING MATERIAL

Plat	Treatment	1905	1906	1907	1908	1909
1	Sprayed every two weeks.	6	5	6	6	6
2	Sprayed every two weeks until shipping began	3	3	3	3	3
3	Sprayed every four weeks.	4	3	3	3	3
4	Sprayed every two weeks until staked.	1	1	1	2	2
5	Sprayed every two weeks after badly infected..........................	4	3	1	5	3
6	Check. Not sprayed.............	0	0	0	0	0

Thus the plants sprayed every two weeks thruout the season usually received six applications; those sprayed until the be-

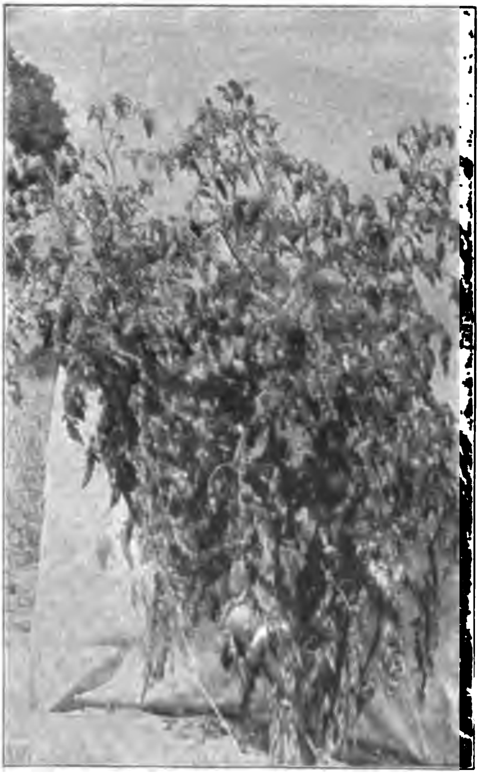

FIG. 13. SPRAYED TOMATO PLANT, FROM PLAT 1, AUGUST 9, 1909.

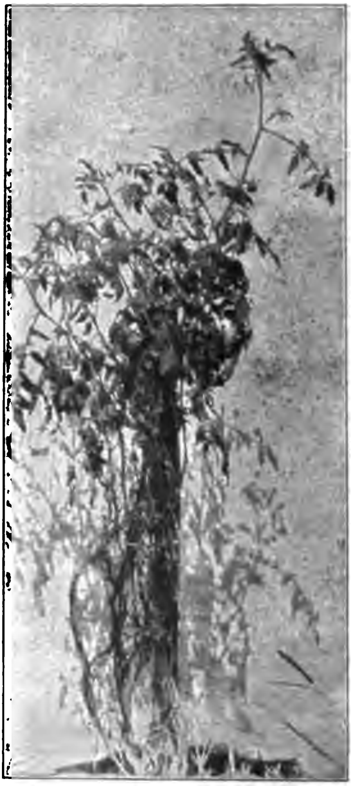

FIG. 14. UNSPRAYED TOMATO PLANT, FROM PLAT 6, AUGUST 9, 1909.

ginning of the shipping season, and also those sprayed every four weeks thruout the season, three applications; and the plants sprayed until staked, either one or two applications. The number of applications made to Plat 5 after the plants became badly infected, varied from 1 to 5, depending upon the relative time of severe infection.

The effect of the spraying was very marked. The progress of the disease was checked in proportion to the amount of spraying. Unsprayed plants lost much of their foliage early and were bare almost to their tips at the close of the shipping season, while the sprayed plants retained their foliage in varying amounts. Altho all plants lost some foliage at the base, those sprayed regularly and often retained sufficient foliage to properly mature their fruit, and were still producing blossoms and green fruit at the close of the shipping season. Specimens of sprayed and unsprayed plants (from Plats 1 and 6, respectively) were photographed August 9, 1909, and are shown in Figures 13 and 14.

EFFECT OF SPRAYING ON YIELD OF FRUIT

The effect of the spraying was further shown by the yield of fruit. Early in the season the unsprayed plants often produced more fruit than those which had been sprayed, but the sprayed plants produced much higher total yields for the entire season.

The fruits classed as early were gathered during the same period as designated in the fertilizer experiments previously reported. The average yields of early tomatoes in pounds per plant are given in Table 16.

TABLE 16—YIELDS OF EARLY TOMATOES, IN POUNDS OF MARKETABLE FRUIT PER PLANT

Plat	Treatment	1906	1907	1908	1909	Average
1	Sprayed every two weeks	.25	1.65	1.02	.32	1.08
2	Sprayed every two weeks until shipping season	.42	1.95	.40	.31	1.02
3	Sprayed every four weeks	.37	1.71	.52	.45	1.01
4	Sprayed every two weeks until tomatoes were staked	.23	1.77	.80	.45	1.08
5	Sprayed every two weeks after badly infected	.34	1.97	.90	.55	1.25
6	Check. Not sprayed	.65	1.78	.74	.65	1.27

These figures show that so far as extra early tomatoes are concerned, there is, on the average, no benefit to be derived from the spraying, for the plats which were not sprayed in the early part of the season produced the highest average yields of early fruit. The fungicide seems to conserve the energy of the plants and cause them to continue growth rather than ripen early fruit.

However, this extra early fruit constitutes only a small part of the entire crop from the sprayed plants. When total yields are considered, the sprayed plants so far outstrip the unsprayed as to completely overcome the slight advantage of the unsprayed plants in reference to early fruit. The total yields from the various plats in terms of pounds per plant are given in Table 17. These yields include only the marketable tomatoes which ripened before the close of the shipping season.

TABLE 17.—TOTAL YIELDS OF MARKETABLE TOMATOES, IN POUNDS PER PLANT

Plat	Treatment	1905	1906	1907	1908	1909	Average
1	Sprayed every two weeks	8.32	1.09	5.93	5.63	2.72	4.73
2	Sprayed every two weeks until shipping began	8.80	1.85	6.05	1.93	2.29	4.18
3	Sprayed every four weeks.....	7.55	1.27	6.02	2.87	2.66	4.07
4	Sprayed every two weeks until staked	5.48	.72	5.52	2.46	1.99	3.23
5	Sprayed every two weeks after badly infected............	4.19	.91	5.73	4.14	1.78	3.35
6	Check. Not sprayed....	3.61	2.30	4.36	2.27	1.82	2.87

The above table shows that regular, frequent applications of Bordeaux mixture are very effective in securing large total yields of marketable tomatoes, and also that early spraying, as on Plat 2, gives much better results than late spraying, as on Plat 5. The exceptional yield from Plat 5 in 1908 was due to the fact that the spraying of this plat was commenced relatively early that year and more applications than usual were made. The conflicting results obtained in 1906 are due to the effects of the wilt which attacked the field in spots. The check plat was in one of the spots not affected early in the season, while the other plats were severely attacked.

These experiments indicate that it is possible to control the leaf spot by spraying. The control of this disease does not usually increase the yield of extra early fruit, but very materially increases the total yield during the normal shipping season. For the most certain results five or six applications should be made at intervals of two weeks, beginning within two weeks after the plants are set in the field.

TOMATO WILT

Reference has already been made to the wilt which appeared in the experimental tomato plantation in 1906. This disease, known as fusarium wilt, is not in the least affected by the application of spraying materials to the plants, and should not be confused with the leaf spot, which, as indicated above, can be effectively controlled by the judicious use of Bordeaux mixture. The wilt has been observed in Union county for a number of years, and has caused the loss of many a promising crop. Affected plants are characterized by a sudden wilting of entire branches, or even the entire plant. Within a few days the wilted portions become brown and dead. Examination of the wilted stems reveals a discolored, brownish appearance of the woody portion. The plants may die before any fruit has matured or after any part of the crop has been gathered.

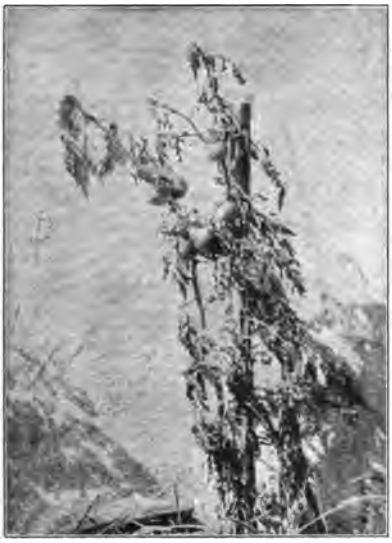

FIG. 15. TOMATO PLANT KILLED BY WILT.

The first season that the wilt appears in a given field, usually only a few plants are infected, but if the same field is used for tomatoes the next year, the attack is likely to be very severe, for the disease is carried over in the soil. The length of time the disease will remain in badly infected soil is not known. It is, therefore, important to practice rotation of crops so that the soil will not become badly infected. Care should also be taken in securing soil for the beds in which the plants are grown. Fresh soil should be put in the beds each year, and it should be secured from a part of the farm which has never grown tomatoes nor received the wash from tomato fields. It is also important to avoid inoculating a new field by means of soil carried from an infected field on tools or the feet of men or farm animals.

HARVESTING AND MARKETING

After a crop of tomatoes has been successfully grown the profits to be realized depend, in a large measure, upon the methods employed in harvesting and marketing.

PICKING

Tomatoes must be picked carefully, and the stems broken off in order to avoid bruising and puncturing the fruits when they are placed in the picking basket. As a further precaution against bruising, some growers line the picking baskets with burlap. The tomatoes are carried or hauled to the packing shed* in these baskets or placed in boxes and hauled in.

If the tomatoes are to be shipped to a distant market, they should be picked when about one-third of each fruit is well colored. At this stage of ripeness the fruits are still firm and will carry in excellent condition. By the time they reach the market, two or three days later, they will be nicely colored. If a local market is to be supplied, the fruits should be riper when they are picked. By picking ever two days, practically all of the fruits can be secured at the proper stage of maturity. However, in hot weather when the tomatoes are ripening rapidly, it is sometimes necessary to pick every day in order to avoid over-ripeness.

Tomato picking is very dirty work. The dirty green stain from the vines which collects on the picker's hands and clothes is difficult to remove. If the hands are rubbed thoroly with a green tomato or a crushed stalk of rhubarb immediately after the picking is completed, the greater part of the stain can be removed. Old garments should be worn while picking tomatoes, and should be reserved for that particular purpose, for it is impossible to keep them clean. Another disagreeable feature about tomato picking is that the tomato vines, as well as the stain from them, have a peculiar odor, which is nauseating to some persons until they have become accustomed to it.

WIPING

Tomatoes which have been sprayed late in the season show the stain of the Bordeaux mixture when they are picked. Those from vines which lie upon the ground are more or less soiled with dirt. In either case the tomatoes should be carefully wiped with a damp cloth before they are packed. This can be done most conveniently as they are being removed from the picking baskets to the packing table.

GRADING

Tomatoes should be graded before they are sent to market. Much of the dissatisfaction with tomatoes on the market, and much loss in the hands of retailers is due to the fact that many tomatoes are sent to market which should never have left the premises of the grower. This applies particularly to specimens which are so badly cracked that the juice oozes from them before they reach the market. One leaking tomato in a crate is likely to ruin the sale of the entire package, for if it leaks enough to be detected, the crate is designated as a "leaker" and is sold at a decided discount. Rough or over-ripe specimens or those of very small size are almost as objectionable, for they spoil the sale of good specimens if placed in the same package, and if packed alone they often fail to bring enough on the market to pay for the expenses of marketing.

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*The construction of packing sheds is fully described in Bulletin No. 124.

In grading tomatoes, then, all badly cracked, rough, over-ripe, or under-sized specimens should be discarded as culls. The salable tomatoes are usually put in one grade, but for discriminating markets, better results would be secured if two grades were made. There is a distinct demand for sound, smooth tomatoes, regular in shape, free from cracks, and of such a size that twelve specimens fill a basket. Tomatoes of this character should be marketed in a grade by themselves, and may be designated No. 1. Sound specimens, slightly inferior to the above in size or smoothness, or with slight cracks about the stem, which have healed over so that there is no danger of their leaking, may be graded as No. 2. Over-grown specimens should also be graded as No. 2. Tomatoes which are so small that over twenty specimens would be required to pack a basket, are not in demand on the market.

If the tomatoes are not uniform in ripeness, each grade should be further sorted, on the basis of color, and only tomatoes uniform in maturity packed in the same crate.

The grading of tomatoes, as well as the wiping (when necessary), is usually done as the fruits are being transferred from the picking baskets or field boxes to the packing table.

PACKING

For local market, no special kind of package for tomatoes is demanded. They are often hauled to market in half-bushel or bushel baskets or in boxes. Usually no special arrangement of the specimens in the package is attempted, tho sometimes the fruits are placed in more or less regular order. For shipment to distant markets, however, special kinds of packages are demanded, and careful placing of the specimens in the package is imperative in order that the tomatoes may reach the market in presentable condition.

PACKING IN CRATES

The standard package for tomatoes produced in Southern Illinois is the four-basket crate. The dimensions of this crate are 22"x13"x4⅜". The baskets are 10"x6¼" at the top and 8½"x 4¾" at the bottom, and 4" deep. Twelve tomatoes of the best grade are packed in each basket. Six specimens are placed, stem side down, in the bottom of the basket, and six more, of a somewhat larger size, are similarly placed on the top. The specimens should fit so tightly that they completely fill the basket, but are not squeezed so much as to be injured. The top layer should extend to the top of the crate, so that when the cover is put on, it will press upon the tomatoes sufficiently to hold them in place. The cover of the crate consists of two slats which are nailed on after the baskets have been filled. These slats are of such a width that the edges of the tomatoes are exposed to view along each side of the basket. This makes an exceedingly attractive package.

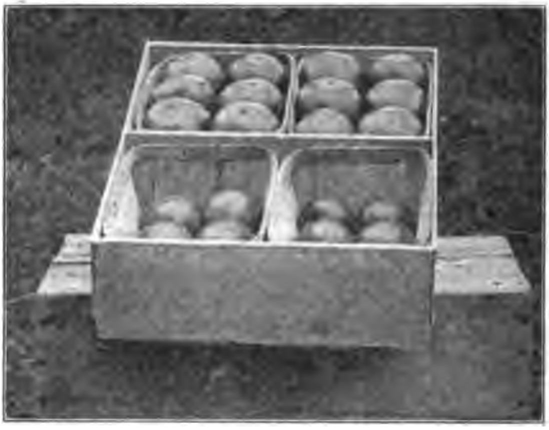

FIG. 16. CRATE OF NO. 1 TOMATOES SHOWING STYLE OF PACK.

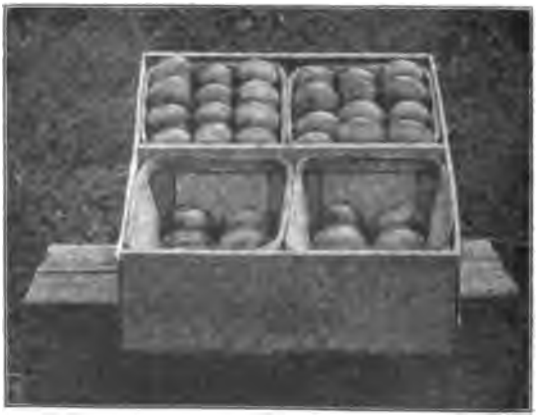

FIG. 17. STYLE OF PACK FOR SMALL TOMATOES.

For smaller sized fruits, the style of pack is varied. Usually it is necessary to place the fruits of the top layer on edge in order to bring them up to the proper height. Care is taken to arrange these fruits so that the blossom ends are exposed to view after the top slats are nailed on the crate.

PACKING IN BASKETS

In some sections of Illinois, especially in localities where the shipping of tomatoes is of minor importance as compared with the shipping of melons, the one-third bushel climax basket commonly used for melons is also used for the tomatoes. In this package the tomatoes are placed in three layers. The arrangement of the specimens in each layer depends upon the size of the fruit. Unless the fruits are exceedingly large it is necessary to pack at least one layer on edge, and in the case of small specimens it may be found necessary to pack two layers in this manner. The packing thruout should be so tight that each specimen will remain exactly where it has been placed. Special care should be taken in the arrangement of the tomatoes in the top layer, so that the package will present a neat appearance. This layer should extend high enough to touch the cover so that the specimens will be held in place, and yet not crushed by the pressure. When used for packing tomatoes the climax basket should be provided with a single-slat, rather than a two-slat, cover, since this type of cover gives the package a more finished appearance.

TYPES OF TOMATOES DEMANDED BY THE MARKET

Formerly only two brands of tomatoes were recognized on the Chicago market—the market which determines the classification of most Illinois tomatoes in so far as they are classified at all. These were known as "Acme" and "Trophy." All large, smooth, purple or pink tomatoes were classed as Acme, while all the bright red or scarlet sorts were classed as Trophy. Most of the bright red tomatoes were more or less rough and wrinkled, so that the bright red color and the roughness of fruit were always associated in the mind of the produce buyer. Thus a strong prejudice against bright red tomatoes was early developed on the Chicago market, and still persists, theoretically at least, in spite of the fact that many extremely smooth varieties of bright red color have been developed. Likewise purple color and smoothness of fruit have long been associated in the mind of the Chicago marketman, since the original Acme tomato was of that color and character. However, the recent introduction of certain extra early, rough-fruited varieties of purple color has somewhat confused the original classification, for some shippers are inclined to brand these rough tomatoes as "Acme" on account of their color. The produce dealers, however, do not recognize this classification, and are beginning to quote these rough, purple sorts by their variety names. In like manner, the shipment of large, smooth, bright red tomatoes is becoming of sufficient extent to warrant a separation of these tomatoes from the old Trophy class in the market quotations and certain leading varities of this character are now sometimes quoted under their variety names. Large, rough-fruited tomatoes of the Ponderosa type are not recognized on the general market, though they may be salable in some local markets.

The Chicago market declares decidedly in favor of tomatoes of the Acme type. The same is true of Peoria, Bloomington and Galesburg. Quincy, Springfield and Decatur do not seem to be so particular as to the color of the tomato so long as the fruit is smooth.

Some of the varieties of tomatoes extensively grown in Southern Illinois which are everywhere recognized as belonging to the Acme type are the Imperial, Livingston's Beauty, Trucker's Favorite, Dwarf Champion and Magnus. The leading variety of the Trophy type is the Earliana, and this has become so predominating a variety of that type that it is often quoted under its own name. The leading rough-fruited varieties with the Acme color are the Earliest Pink and June Pink. Some of the best varieties of smooth, bright red tomatoes are Chalk's Early Jewel, Stone and Matchless.

Tomatoes of the Trophy type, especially the Earliana, are grown quite extensively on account of their extreme earliness. Earliest Pink and June Pink are being grown to some extent, for the same reason. These varieties usually bring good prices if there are no other tomatoes on the market, but as soon as the market is supplied with smooth varieties, there is little demand for these rough sorts. Even at their best, these varieties produce a high percentage of culls, and should, in most cases, be discarded by all growers who desire to produce tomatoes acceptable to the trade. With well-grown plants of a slightly later variety, but one which produces large, smooth fruits, the careful grower can practically control the early tomato market of his locality. For shipment to the city markets also, it is unwise to depend upon rough-fruited sorts, for even if early, they usually must compete against smooth later sorts from more southern localities.

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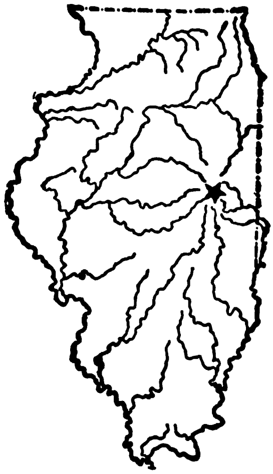
QUANTITATIVE RELATIONSHIPS OF CARBON, PHOSPHORUS, AND NITROGEN IN SOILS

(SECOND EDITION, MAY, 1912)

BY ROBERT STEWART



URBANA, ILLINOIS, APRIL, 1910

The Station.

CONTENTS OF BULLETIN No. 145

PAGE

A. Historical Résumé

1. Carbon in Soils 91
2. Nitrogen in Soils 94
3. Phosphorus in Soils 96
4. Carbon and Nitrogen in Fundamental Rocks 103

B. Experimental Part

1. Mathematical

(a) Influence of Age upon the Carbon-Nitrogen Ratio 105
(b) Carbon, Nitrogen and Phosphorus in Illinois Soils 108
(c) Factors for Calculating Organic Phosphorus 110

2. Chemical

(a) Analytic Results of Soil from Illinois South Experiment Farm 111
(b) Phosphorus Associated with the *Matière Noire* 112
(c) Organic Phosphorus by Schmoeger's Method 119
C. Conclusions 121
D. Bibliography 123

QUANTITATIVE RELATIONSHIPS OF CARBON, PHOSPHORUS AND NITROGEN IN SOILS*

By ROBERT STEWART

(A) HISTORICAL RÉSUMÉ

The literature on carbon, nitrogen and phosphorus in soils is voluminous. The résumé given herewith by no means attempts to include all that pertains to these elements in the soil, but it is confidently believed that it fairly represents the literature pertaining to this particular phase of the subject.

I. CARBON IN SOILS

Carbon may exist in soils as inorganic and as organic carbon. The agricultural value of organic carbon, or organic matter, of soils has long been recognized by the practical husbandman, and the scientific man early recognized its value when the applications of science were made to agricultural problems.

Mülder (1), in 1844, made an elaborate study of the organic matter of the soil, and seems to have been the first one to suggest that it consisted of other elements than carbon, hydrogen and oxygen. He separated the organic matter into various supposedly pure organic compounds of an acid nature, which were analyzed and studied by the usual organic method.

Wolff (2) determined the organic matter of the soil by calculation, by use of the factors 1.724 or 0.471; he multiplied the organic carbon by the former factor, or the total organic carbon dioxid by the latter. The factors were derived from the conception that "humus" contained 58 percent carbon.

Detmer (9) attempted to isolate "pure" humic acid from the soil and to study its properties. He obtained a fairly pure product which he studied and submitted to analysis.

A little later Grandeau (10) developed his well known method for determining the *matière noire* of soils, which he regarded as of great importance. He stated that soils owed their color and probably their fertility to its presence, since it held in combination phosphorus, nitrogen, and certain mineral elements.

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*Submitted to the Faculty of the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June, 1909.

Dehérain (22) determined the carbon content of soils from plots which had received different treatment. He found that the soils from the plots which had not been manured had lost over 50 percent of their carbon.

Kostytschiff (24) studied the humus obtained from substances of known origin and which were converted into humus under controlled conditions. He learned that even with the albuminous substances the carbon was lost more rapidly than the nitrogen, hence the ratio of carbon to nitrogen would be narrower in the resulting humus than in the original material.

Berthelot and André (31) found that 67.1 percent of the total carbon in soils was soluble in dilute alkalis but that over one-half of this soluble carbon, or 40 percent of the total carbon, was not precipitated from the alkalin solution by the addition of an acid.

Snyder (37) reported the results obtained by a study of the production and analysis of the humus obtained from such substances as cow manure, clover, meat scrap, etc., etc., which were converted into humus under known conditions. The carbon content of the humus varied from 41.95 percent in case of the humus produced from cow manure to 57.84 percent in case of the humus produced from cane sugar.

Hess (45) studied the effect of different systems of treatment on the humus of the soil. He found that the ratios of carbon to nitrogen and nitrogen to humus were not materially affected by the treatment applied.

André (47) studied the action of potassium hydroxid on the carbon compounds of the soil, mould, compost and peat. He determined the insoluble and soluble carbon; the latter he separated into two classes; the portion precipitated from alkaline solution by the addition of an acid, and the portion remaining in solution. The results obtained are expressed in Table 1.

TABLE 1.—PERCENTAGE OF SOLUBLE AND INSOLUBLE CARBON AND RATIO OF CARBON TO NITROGEN

		Peat		Compost		Soil		Mould	
		Ratio of C/N	Percent carbon of total	Ratio of C/N	Percent carbon of total	Ratio of C/N	Percent carbon of total	Ratio of C/N	Percent carbon of total
Insoluble portion		147.6	24.5	84.4	40.0	82.4	35.4	40.4	41.8
Soluble portion	a. Precipitated by acids	26.9	44.8	16.6	23.0	27.1	36.6	10.8	18.7
	b. Not precipitated by acids	17.7	30.7	9.8	37.0	16.7	28.0	10.1	39.5

The ratio of carbon to nitrogen in the original material was: peat 22.7; compost 15.0; soil 24.7; and mould 12.8. He concluded that the more insoluble the compound the wider was the carbon-nitrogen ratio. The potassium hydroxid showed a tendency to dissolve the compounds rich in nitrogen.

Pagnoul (51) found no fixed relation between the carbon and nitrogen of the soil, but apparently the carbon, nitrogen, and humus varied in the same direction, altho irregularly.

Rimbach (53) concluded that since the *matière noire* was readily nitrified it was the direct source of the nitrates of the soil, and thus the insoluble carbon was of insignificant value.

Frear and Hess (54) found that lime caused a more rapid loss of carbon than of nitrogen in manured land, but the reverse in unmanured land.

Dyer (55) studied the carbon and nitrogen content and the relationship between carbon and nitrogen in the soil taken from 22 different plots of the Rothamsted experiment fields. These data are furnished for each individual 9-inch section to a depth of 90 inches.

The carbon and nitrogen contents of the higher depths were higher than those of the lower depths and the ratio of carbon to nitrogen is wider in the former. At the fifth to sixth depth the carbon and nitrogen contents seem to become fixed quantities and are apparently those derived from the original matter out of which the soil was formed.

A study of various clays and other material taken from great depths seemed to indicate that a nitrogen content of .04 percent was indigenous to the subsoil of the Rothamsted station.

Cameron and Breazeale (61) investigated the three general methods for determining the carbon content of the soil: namely, the "loss on ignition" method, the humus method, and two forms of a combustion method. They concluded that the first two methods were unreliable: the first, because there was no apparent relationship existing between the results obtained and the true carbon content; the second, since it made no pretense of giving the total carbon in the soil.

It is interesting to note that they reported that the ammoniacal extract contained so much suspended material that it was found undesirable to work with until it was passed thru a Chamberland-Pasteur filter, when a perfectly clear solution was obtained.

König (67) recently studied the influence of hydrogen peroxid on the organic matter of the soil. He found that it consisted of two parts, one easily oxidized by hydrogen peroxid, the other not oxidized by this reagent.

Hopkins and Pettit (68) reported the total carbon, nitrogen and phosphorus contents of a great number of samples of the soils of Illinois. This work is thus made the basis of calculating the relationship of carbon, nitrogen and phosphorus reported in part (B) of this thesis.

2. NITROGEN IN SOILS

The nitrogen in soils exists chiefly as organic nitrogen with a very small amount of inorganic nitrogen. The organic nitrogen may exist in some known and probably some unknown forms.

Mulder (1) believed the nitrogen found in the humus to be associated with the organic matter in the form of the ammoniacal salts of the various organic acids obtained by him.

Müller (4) thought he detected a tendency for the nitrogen to vary inversely as the carbon.

Detmer (9) believed that the nitrogen formed a definite compound with the organic carbon of the soil since the nitrogen could be liberated only with great difficulty and by the use of the most drastic chemical agents.

Simon (11) believed that the organic matter of the soil possessed the property of absorbing the free nitrogen of the atmosphere and of converting it into ammonia which in turn united with the organic acids in the form of their ammoniacal salts. Sostegni (19) a little later discussed the work of Simon and reported a series of experiments to prove that Simon's assumption was untenable.

Berthelot (19), in 1886, reported the carbon and nitrogen contents of calcareous clayey soil, originally very deficient in organic carbon and nitrogen but which was gradually increasing in carbon and nitrogen content owing to the action of diatoms.

Berthelot and André (20, 74, 75, 76) later carried on a series of experiments for the purpose of separating the organic nitrogenous material into its various compounds. They reported the amount of total, nitric, amido and ammoniacal nitrogen present in the soil.

Eggertz (21) differed very materially from Mulder. He concluded that Mulder's contention, that the nitrogen associated with the organic matter of the soil existed only as the ammoniacal salts of the various organic acids, was untenable. If the nitrogen existed simply as the ammoniacal salt of the humic acid, treatment with hydrochloric acid should liberate *all* the nitrogen as ammonia, which, experimental evidence showed, was not the case.

Furthermore, artificial humic acid, treated with ammonia, did form ammonium humate, which, however, was readily decomposed by treatment with a mineral acid; yet, if this artificial humic acid be *heated* in a current of ammonia gas, combination took place, and the resulting compound could not be decomposed by treatment with mineral acids. He therefore concluded that the nitrogen formed an integral part of the humic acid radical.

Berthelot and André (26) studied artificial humic acid prepared out of sugar. This acid formed salts with various bases, which were easily decomposed again by treatment with an acid, *except* in the case of the *ammonium salt*, the nitrogen of which could not be entirely liberated by this treatment. They concluded that the nitrogen, in part at least, formed an integral part of the humic acid radical.

Hilgard and Jaffa (30), in 1892, propounded their well known view regarding the importance of the nitrogen associated with the extracted *matière noire*.

Berthelot and André (31) regarded the organic matter of the soil as of great importance since it prevented the loss of nitrogen thru drainage and since the nitrogen was held in insoluble combination in the organic matter.

Fulmer (38) determined the humic nitrogen in 53 samples of Washington soil and attempted to work out the relationship between carbon and nitrogen by means of the formula $c = \frac{b \times 55}{a}$, where c = the percentage of nitrogen in the *matière noire;* b = the percentage of the total soil nitrogen; a = the percentage of humus. By means of this formula the 53 samples of soil were separated into three classes; the first class contained 19 samples in which the variation in the humic nitrogen calculated by means of the formula was within one percent of the analytical result; the second class contained 10 samples and the variation was from one to two percent; the third class contained 24 samples and the variation was anywhere over two percent. These results furnished good evidence that no one given relation would hold for all soils.

Wheeler (48) found that both lime and gypsum caused a decrease in the amount of humus but that the percentage of humic nitrogen was increased. Similar results were obtained by Frear and Hess (54) on manured land.

Dojarenko (56) recently studied the "humic" nitrogen of soils. He determined the total, humic, amid, ammoniacal and amido nitrogen in seven samples of black Russian soils. The results are reported in Table 2.

TABLE 2.—PERCENTAGE OF TOTAL HUMIC, AMIDO, AMID AND AMMONIACAL NITROGEN IN HUMUS

No.	Percent in dry substance				Percent of total quantity of nitrogen		
	Total humic nitrogen	Amido nitrogen	Amid nitrogen	Ammoniacal nitrogen	Amido nitrogen	Amid nitrogen	Ammoniacal nitrogen
1	2.735	1.34	0.31	0.04	49.09	11.38	1.46
2	3.38	1.81	0.41	0.08	53.55	12.13	2.36
3	2.64	1.30	0.29	0.02	49.20	10.99	0.80
4	3.33	2.34	0.32	0.03	70.27	9.61	0.90
5	4.58	1.01	0.48	0.06	22.01	10.46	1.31
6	3.65	1.26	0.27	0.07	34.52	7.40	1.90
7	4.02	1.96	0.22	0.03	48.75	5.47	0 78

This did not account for all of the nitrogen present and so the question arises, In what form does the remainder exist?

D'Utra (70) found that the humic nitrogen showed wide variations.

Hilgard (71) reported the average humic nitrogen of 466 samples of soil from the humid regions as 5.45 percent, while the average of 313 samples of soil from the arid section was 15.87 percent. Later (73) he found that the average humic nitrogen for 696 samples of humid soil was 5.00 percent, while that of 573 samples of arid soil was 15.23 percent. It must be remembered, however, that the total quantity of nitrogen of the two regions is in the inverse order. The total nitrogen of the uplands and lowlands of California, for example, is 0.101 percent and 0.101 percent respectively, while the total nitrogen of the ordinary brown silt loam soils of the corn belt in Illinois varies from 0.218 percent to 0.337 percent.

3. PHOSPHORUS IN SOILS

The phosphorus of the soil may exist in the inorganic and in the organic condition. The greater part is in the inorganic form, with an unknown amount in the organic state. The form and amount of the organic phosphorus is uncertain, and indeed it has been questioned, especially during recent years, whether or not organic phosphorus occurred in the soil to any appreciable extent.

Mulder (1), as early as 1844, noted that the organic material was not readily freed from phosphorus.

The work of Thenard, and of Schutzenber (5, 6, 7) showed that union may take place between various forms of artificial humus and phosphates under certain conditions and indicated that combination may possibly take place in the soil between organic carbon and inorganic phosphorus.

Detmer (9) in the preparation of his "pure humic" acid, noted that the material could be freed from phosphorus only with great difficulty.

Grandeau (10) regarded the phosphorus associated with the extracted *matière noire* as being of the greatest importance and probably in special combination with the organic matter. He regarded it as an index of the fertility of the soil.

Simon (11) believed that he had demonstrated that union took place between organic matter and phosphates. When freshly precipitated humic acid was suspended in water and digested with calcium phosphate and then filtered, the filtrate showed an excess of phosphoric acid: this excess, he concluded, must be in union with the organic matter in solution. He thought that a double compound of ammonia and phosphorus existed in the soil.

Schultz (12) showed that the addition of humus to "Basaltböden" increased the absorption ability of the soil for phosphates.

Eichhorn (13) repeated some of Simon's work and concluded that organic combination did not take place as indicated by Simon but that the humus had decomposed the tri-calcium phosphate with the formation of acid phosphate.

Pitsch (14) determined the solubility of the various mineral phosphates, including iron and aluminium phosphates, in a solution of *ammonium humate itself*. He concluded that since this solution exerted a solvent action on mineral phosphates, the ammonia extract of the soil contained phosphorus other than that originally associated with the organic matter in the soil and probably part, at least, of the ammonia-soluble phosphorus was derived from the iron and aluminium phosphates.

M. P. DeGasparin (15) found in calcareous clay soil 5 percent of the total phosphorus in organic combination. He noted, furthermore, that the mosses and lichens contained from 5 to 6 times as much phosphorus as the rocks on which they grew; the soil formed, therefore, from the debris of these plants should be relatively richer in phosphorus and should have a part of its phosphorus in combination with carbon in the organic material.

Eggertz (21) found that the ammoniacal extract of the soil, when treated with an acid, formed a precipitate of organic matter which always contained phosphorus. He concluded, therefore, that part of the phosphorus of the soil was united to the carbon in organic combination.

Later Eggertz and Nilson demonstrated that the amount of phosphorus soluble in dilute mineral acids showed a marked increase after ignition of the soil. Ignition rendered 10 times as much phosphorus soluble in 2 percent hydrochloric acid. They attributed this to the destruction of the organic matter which had held the phosphorus in combination and which would not yield up its phosphorus to acids.

Van Bemmelen (23) believed that the iron, calcium, silica, phosphoric acid, etc., found in the ash of the *matière noire* by Eggertz, were not originally chemically combined to carbon in the organic matter of the soil but were absorbed by the precipitated gelatinous *matière noire*. According to Van Bemmelen the phosphorus existed in the soil principally as calcium phosphate with a very small quantity occurring in the absorbed state in the form of a *colloidalen Humate-Silicat-Komplex*.

Two questions seemed to be of paramount importance to Wiklund (25) regarding the work of Eggertz: First, was the amount of the ammonia-soluble phosphorus obtained from different soils constant? Second, did the phosphorus exist in the mullkörpers (*matière noire* of Grandeau) in chemical combination with carbon, or simply as absorbed phosphorus? He concluded that there was a tendency for the ammonia-soluble phosphorus to be constant in different soils. He showed, further, that one digestion with 12 percent hydrochloric acid did not completely remove all of the acid-soluble phosphorus, but a second and even a third digestion still removed some phosphorus. Now, he reasoned, if the phosphorus removed by the second and third digestion was simply extracted from the absorbed phosphorus, extraction of the soil with ammonia after the first digestion with hydrochloric acid should yield a solution of *matière noire* containing a higher phosphorus content than when the soil was completely extracted with the hydrochloric acid. Such, however, was not the case; therefore, the phosphorus did not exist as absorbed phosphorus and must be in combination with carbon in the organic matter.

Snyder (34) noted that some phosphorus, iron, etc., were extracted with the *matière noire* but he did not seem to think at this time that there was any evidence of combination with carbon. About the same time he observed the rapid loss of phosphorus associated with the humus in continuously cultivated soil.

According to Berthelot and André (27) phosphorus may be found in the soil (a) in inorganic or mineral phosphates, (b) in organic ethers and (c) in organic or mineral compounds not readily decomposed.

Schmoeger (29) reviewed the rival claims of Eggertz and Nilson, and Wiklund, on the one hand, and Van Bemmelen, on the other, regarding the phenomenon of ignition rendering the phosphorus of peaty soil more readily soluble in acids.

It seemed possible to Schmoeger that the soil might possess such a tenacious absorbent power for phosphorus that it would not yield up its phosphorus to acid treatment before ignition. But he deduced experimental evidence to show that such was not the case.

Digestion of the soil itself and also the extracted *matière noire* with a solution of potassium hydrogen phosphate failed to add any phosphorus which was not again recovered by treatment with hydrochloric acid. This was conclusive evidence to Schmoeger that the phosphorus did not exist as absorbed phosphorus and must, therefore, exist in organic combination. Two possibilities suggested themselves to Schmoeger: first, the phosphorus existed in the form of lecithin; second, it existed as nuclein. Lecithin was found to be present only in traces. The characteristic property of nuclein to "split-off" its phosphorus in the form of phosphoric acid, when heated under pressure in the presence of water to a temperature of 150°-160°, was utilized by Schmoeger. The soil under examination, treated in this way, yielded as much soluble phosphorus as did the ignited soil. This experimental evidence led him to conclude that nuclein or some closely allied bodies were present in the soil.

Later Schmoeger (39) confirmed his previous work and produced additional evidence in favor of his view that nuclein or similar bodies existed in the soil. Table 3 shows some of the results obtained.

TABLE 3.—PERCENTAGE OF SULFURIC ACID AND PHOSPHORUS SOLUBLE IN DILUTE ACID

	Percent	
	Sulfuric acid	Phosphorus
Soil in original state	0.122	0.043
Evaporated soil	0.290	0.083
Ignited soil	0.939	0.095

Since sulfur is regarded by many authors as being a constituent of plant nuclein, the increased solubility of this substance, together with the phosphorus when the soil was treated as indicated above, was regarded as evidence in favor of his assumption.

In a later article (40) he showed, by similar treatment, that analogous bodies existed in the moor grass out of which the moor soil was formed. This was regarded as additional evidence in favor of his view.

Tacke (33) observed that the drying out of soil rendered the phosphorus available. There were three possible explanations suggested to him: first, the phosphorus existed in the soil in organic combination which was destroyed by the process of drying; second, it existed in the soil in the colloidal form as suggested by Van Bemmelen; third, the drying out of the soil gave rise to substances of a strong acid nature which acted upon the insoluble phosphorus compounds rendering the phosphorus soluble.

In a later article (42) he showed that very little water-soluble phosphorus existed in the soil under consideration, but that drying at 70°-80° rendered over 50 percent of the total phosphorus soluble in water.

Snyder (36) reported results of a confirmative nature regarding the phosphorus associated with the humus in virgin and cultivated soils.

Later (37, 41) he studied the product obtained by the conversion of known substances, under known conditions, into humus. The ash of the *matière noire* obtained from this material contained phosphorus, among other substances, and according to Snyder, "There is every indication that these elements are in organic combination with the carbon, hydrogen and oxygen of the humus." As regards the question whether or not the humus united with the inorganic phosphorus of the soil, he concluded that his experimental evidence showed that such union did take place.

Nannes (49) found that a well decomposed peat soil contained 0.166 percent phosphorus. He found that 0.057 percent of phosphorus was extracted with the *matière noire*. When the ammoniacal solution of the *matière noire* was treated with hydrochloric acid, 0.039 percent of the phosphorus was found in the organic precipitate. He also attempted to isolate a definite organic phosphorus compound and he believed that he detected the presence of lecithin and chlorophyllan.

Ladd (43) found in a study of eight samples of different soil that an average of 41 percent of the phosphorus was associated with the extracted *matière noire;* the variation, however, was from 10 percent to 90 percent.

In a later article (44) he showed that as the humus of the soil increased the phosphorus associated with the extracted *matière noire* also increased. From the fact that the organic precipitate, formed by neutralizing the ammoniacal extract, contained the phosphorus, he concluded that it existed in the soil in organic combination, but just what was the relationship was not clear.

Emmerling (52) believed that there were four forms of phosphorus in the soil, one of which was phosphorus in organic combination.

Rimbach (53) found 6.15 percent P_2O_5 in the ash of the *matière noire* which was precipitated from the ammoniacal solution by the addition of gypsum and magnesium sulfate.

Nagaoka (57) found that ignition of the soil for fifteen minutes at a faint red heat materially increased the availability of the phosphorus. He attributed this action to the destruction of the humophosphates.

Asō (58) confirmed, in a general way, the results obtained by Schmoeger. He also found 0.049 percent of lecithin in the soil. He drew the following conclusions:

1. Phosphorus existed in the soil as inorganic and as organic compounds.
2. The organic phosphorus material was principally nuclein with a very small part of lecithin.
3. Ignition rendered the phosphorus in organic combination available.

Hartwell and Kellogg (60) found that an average of one-half of the phosphorus was associated with the organic matter in the soil taken from four plots which had received different treatment.

Dumont (62) studied a complete manure, the composition of which was as follows: soluble matter (in dilute alkali) 50.4 percent; insoluble matter 49.6 percent; total nitrogen 1.6 percent; total phosphorus 1.27 percent.

The soluble portion contained 35 percent of the nitrogen and 46 percent of the phosphorus. In order to obtain data upon the state of combination of the phosphorus, the ammoniacal solution of *matière noire* was treated with various reagents with the result (recalculated to the element basis) shown in Table 4.

TABLE 4.—DISTRIBUTION OF PHOSPHORUS WHEN *Matière Noire* IS PRECIPITATED

Precipitating agent	Phosphorus	
	In precipitate	In filtrate
Citric acid	0.383	0.203
Hydrochloric acid	0.386	0.199
Ferric chlorid	0.532	0.053
Aluminium sulfate	0.566	0.019
Calcium chlorid	0.584	0.0009

These results furnished conclusive proof to Dumont that a part of the phosphorus of the soil was in organic combination.

Later (64) he obtained better cultural results from application of humic phosphatic manures than from mineral phosphatic manures and better even than from barnyard manure, which he attributed to the phosphorus in organic combination.

In a still later article (65) he said that the organic phosphorus was derived from two sources: first, from the nuclein and lecithin of the decaying vegetable and animal debris; second, from the union of the humus with the water-soluble phosphates of the soil.

Evidence of the latter contention was obtained by precipitating the *matière noire* in the presence of potassium hydrogen phosphate by different reagents as indicated in Table 5.

TABLE 5.—AMOUNT OF PHOSPHORUS IN PRECIPITATED HUMUS AND FILTRATE

Precipitating agent	Series A Phosphorus introduced=.087		Series B Phosphorus introduced=.218		Series C Phosphorus introduced=.437	
	Phosphorus in humus	Phosphorus in filtrate	Phosphorus in humus	Phosphorus in filtrate	Phosphorus in humus	Phosphorus in filtrate
Acetic acid	0.056	0.031	0.057	0.160	0.058	0.374
Citric acid	0.054	0.033	0.055	0.163	0.054	0.381
Hydrochloric acid	0.057	0.030	0.059	0.158	0.059	0.378
Sulfuric acid.....	0.057	0.030	0.061	0.156	0.062	0.372

Altho the amount of dipotassium phosphate added to the solution had increased, the amount of phosphorus absorbed by the humus was practically constant, due to the formation of definite "composés phospho-humique."

König (67) found that hydrogen peroxid oxidized from 40 percent to 70 percent of the humus present in the soil and that much more of the phosphorus was soluble in pure and carbonated water after oxidation than before, due, he believed, to the destruction of the organic phosphorus compounds.

Fraps (69), quite recently, made a study of the phosphorus extracted from the soil by 4 percent ammonia in the usual determination of humus. He confirmed Pitsch's results regarding the possibility of some of the ammonia-soluble phosphorus being of inorganic matter. He separates the ammonia-soluble phosphorus into three classes as follows:

1. The phosphorus associated with the clay held in suspension in the liquid.
2. The phosphorus precipitated with the organic matter when the solution was neutralized with an acid.
3. The phosphorus which remained in solution after the precipitation of the organic matter.

With the soils under consideration he found that 1/9 of the ammonia-soluble phosphorus was in the first class, 1/3 was in the second class and 5/9 was in the third class.

The phosphorus found in the first class was assumed to be associated with the clay particles as iron and aluminium phosphates. He concluded that the phosphorus precipitated with the organic matter from the ammoniacal solution by the addition of acids was in organic combination. The phosphorus remaining in the mother liquor was assumed to be derived from the iron and aluminium phosphates of the soil.

Mooers and Hampton (77) recently proposed a method for obviating the error introduced in the humus determinations by the suspended clay. They claimed that filtration thru the Chamberlain-Pasteur filter, as suggested by Cameron, introduced a serious error inasmuch as the filter absorbed some organic matter. They proposed an evaporation method: by evaporation of the ammoniacal extract to dryness and re-dissolving in ammonia and filtration several times, a perfectly clear solution was obtained. Determination of the humus in this filtrate gave very concordant results.

Hopkins and Pettit (68) found that in certain soils the mineral composition had a tendency to be constant in the surface, subsurface, and subsoil. This was indicated by the uniform potassium content of the surface, subsurface, and subsoil and by the fact that different samples of surface soil of the same type showed a wide variation in the phosphorus content but that this variation largely disappeared in the subsoil. The potassium exists in the soil in the inorganic form, the nitrogen exists chiefly in the organic form, while the phosphorus may exist in the inorganic and in the organic state. They suggested, therefore, a method for calculating the phosphorus in the organic state in the surface soil. The difference in amount of nitrogen in the surface soil and subsoil, and the difference in the amount of phosphorus in the surface soil and subsoil gave apparently the amount of nitrogen and phosphorus associated together in organic combination. By means of this ratio and the total amount of nitrogen in the surface soil the total amount of organic phosphorus present in the surface soil could be calculated.

4. CARBON AND NITROGEN CONTENT OF FUNDAMENTAL ROCKS

The fundamental rocks out of which soils have been formed contain an appreciable amount of carbon and nitrogen which is indigenous to them.

Dellese (3) discovered that mineral matter (crystalline, sedimentary and eruptive) contained carbon associated with nitrogen. This mineral matter, which was formed under similar conditions of temperature, pressure, etc., had a tendency to contain a constant amount of carbon and nitrogen.

The work of Lawes and Gilbert (16), Dyer (55) and Hall and Miller (66) on the clays and other fundamental rock material taken from various great depths indicated that an appreciable amount of carbon and nitrogen was indigenous to the underlying soil material.

(B) EXPERIMENTAL PART

The starting point of such an investigation consists of a consideration from a mathematical point of view of the existing data regarding the relationships of carbon, phosphorus and nitrogen in the soil.

I. MATHEMATICAL

(a) INFLUENCE OF AGE UPON THE NITROGEN-CARBON RATIO

From the data available in the literature it is possible to determine within certain limits the influence of age upon the nitrogen-carbon ratio in soils. From the average results of a number of nitrogen determinations (68) and the carbon content obtained by calculation from the proximate analysis, it is possible to determine the approximate nitrogen-carbon ratio in the more common humus producing materials. The results obtained in this way will be found in Table 6. The materials naturally fall into two groups: in the first group the ratio varies from 1 :52.2 for corn stover to 1 :84.1 for wheat straw; in the second group the variation is from 1 :16.7 for alfalfa hay to 1 :35.4 for timothy hay.

TABLE 6.—APPROXIMATE NITROGEN-CARBON RATIO IN THE MORE COMMON HUMUS PRODUCING MATERIALS

Kind of material	Carbon to 1 of nitrogen
Corn stover	52.2
Oat straw	67.8
Wheat straw	84.1
Timothy hay	35.4
Clover hay	21.3
Cowpea hay	19.5
Alfalfa hay	16.7
Albumin	3.2
Zein	3.4
Nuclein	2.8

In Table 6 will also be found the nitrogen-carbon ratio in some of the compounds which might be expected to be found in humus. The ratio is very narrow and does not vary much from 1 :3.

The next step in the study of the influence of age upon the nitrogen-carbon ratio would be to determine the ratio in as fresh humus as possible from known materials. Snyder (35), in his study of the production of humus from known materials, placed a weighed quantity of the material, together with a weighed quantity, of soil having a low humus content, in a box and set it aside for one year. At the end of the experiment the humus was extracted and the carbon and nitrogen determined in the *matière noire.* At first thought this would appear to furnish the desired information, but unfortunately no check was run with the untreated soil; so no correction can be made for the carbon and nitrogen which may have been converted into humus from the unhumified material of the soil. This is evidently not a quantity which can be ignored, since the humus content of the original soil is .06 percent while the total nitrogen of the soil is .02 percent, showing that considerable unhumified organic matter was present; otherwise the humic nitrogen would be 33.33 percent, while it has been shown (71) that the humic nitrogen would more probably be nearer 5 percent. In addition, the fact that the humus obtained from sugar contains some nitrogen is evidence that some of the unhumified organic matter of the soil has been converted into humus, since sugar does not contain nitrogen. The results, however, will be found in Table 7. In the first five substances the variation is from 1:21.7 for oat straw to 1:4.5 for meat scraps.

TABLE 7.—MINNESOTA SOIL STUDIES: HUMUS PRODUCTION FROM KNOWN MATERIALS

Material used	Percent			Ratio of carbon to 1 of nitrogen
	Humus	Carbon in humus	Nitrogen in humus	
Original soil	0.06	?	?	?
Cow manure	0.58	41.95	6.16	6.8
Clover	0.37	54.22	8.24	6.6
Meat scraps	0.31	48.77	10.96	4.5
Oat straw	0.46	54.30	2.50	21.7
Flour	0.47	51.02	5.02	10.2
Sawdust	0.59	49.28	0.32	153.8
Sugar	0.32	57.84	0.08	741.0

The large number of carbon and nitrogen determinations made of the soils of Illinois (68) rendered it possible to determine the nitrogen-carbon ratio not only for the surface soil but also for the subsurface and subsoil. The average of 19 determinations for the soil type gray silt loam on tight-clay, gave the ratios 1:10.4, 1:8.8, and 1:7.6 for the surface, subsurface, and subsoil respectively. The ordinary brown silt loam soils, as an average of 68 determinations, gave a nitrogen-carbon ratio of 1:12.1, 1:11.5 and 1:8.9 for the surface, subsurface and subsoil respectively. The black clay loam soils, as an average of 25 determinations, gave 1:11.7, 1:11.9 and 1.9 respectively in the surface, subsurface, and subsoil. The peat soil, as the average result of 5 determinations, gave 1:11.8 and 1:12.9 for the surface and subsoil respectively.

TABLE 8.—RATIOS OF CARBON AND NITROGEN IN ILLINOIS SOILS

Soil type No.	Soil types	No. of analyses on which calculations are based	Carbon to 1 of nitrogen		
			Surface	Sub-surface	Subsoil
330	Gray silt loam on tight clay........	19	10.4	8.8	7.6
426	Brown silt loam	11	12.5	11.7	9.6
526	Brown silt loam	8	13.2	12.9	8.7
626	Brown silt loam	6	11.4	10.5	8.7
726	Brown silt loam	4	11.9	11.1	8.8
1126	Brown silt loam	30	11.9	11.5	8.6
1026	Brown silt loam	9	12.0	11.5	9.3
Averages		68	12.1	11.5	8.9
420	Black clay loam	7	12.2	12.2	8.9
520	Black clay loam	5	12.4	12.2	11.4
1120	Black clay loam	11	11.1	11.1	8.3
1220	Black clay loam	2	11.2	12.2	7.4
Averages		25	11.7	11.9	9.0
1401	Deep peat	5	11.8	12.9	12.9

The Rothamsted work furnished information regarding the nitrogen-carbon ratio of the soil in 9-inch sections to a depth of 90 inches. These results will be found in Tables 9 and 10. The ratio for the Broadbalk wheat fields varies from 1 :9.5 to 1 :4.8 for the surface and ninth 9 inches respectively. After the fifth 9 inches there is very little change in the ratio. In the Hoosfield barley soils the ratio varies from 1 :10.6 to 1 :8.8 for the surface and subsoil respectively.

TABLE 9.—BROADBALK WHEAT SOILS: RATIO OF CARBON TO NITROGEN

Depth	Percent		Carbon to 1 of nitrogen
	Carbon	Total nitrogen	
First 9 inches (all plats)..............	1.155	.1223	9.5
Second 9 inches	.640	.0784	8.2
Third 9 inches........................	.492	.0666	7.4
Fourth 9 inches	.339	.0511	6.6
Fifth 9 inches	.279	.0472	5.9
Sixth 9 inches	.256	.0430	5.9
Seventh 9 inches	.248	.0420	5.9
Eighth 9 inches	.215	.0396	5.4
Ninth 9 inches........................	.189	.0391	4.8
Tenth 9 inches........................	.188	.0375	5.0

TABLE 10.—HOOSFIELD BARLEY SOILS: RATIO OF CARBON TO NITROGEN

Depth	Carbon to 1 of nitrogen
First 9 inches........................	10.6
Second 9 inches......................	8.8
Third 9 inches	8.8

Hall and Miller (66) reported the carbon and nitrogen content, and the ratio of carbon to nitrogen, in samples of various materials taken from such great depths as to preclude all possibility of weathering. Since the nitrogen was always found to be associated with carbon it was regarded as being of organic origin and as being derived in part from the organic matter present in the clay at the time of its deposit. These results are shown in Table 11.

TABLE 11.—CARBON AND NITROGEN IN UNWEATHERED ROCKS

No. of soil	Formation	Depth at which sample was taken, ft.	Percent		C/N Ratio
			Organic carbon	Nitrogen	
1	Lower Bagshot Sand, Weybridge..	18—20	0.02	.00384	5.4
2	Upper Greensand, Farnham, Surrey	30	0.032	.00718	4.5
3	Folkestone Beds, Brabourne, Kent	20	0.019	.00453	4.2
4	Lower Greensand, Sevenoaks....	30	0.076	.00881	8.7
5	London Clay, London	130	0.391	.041	9.5
6	Gault Clay, Nackholt, Kent	18	0.427	.0415	10.3
7	Weald Clay, Pluckley, Kent.......	30	0.135	.0647	2.1
8	Carboniferous Shale, Barnsley....	1236	1.938	.137	14.1
9	Lower Gault, Dover......	280—400	0.172	.0325	5.3
10	Oxford Clay, Dover	920	0.548	.0528	10.4
11	Kimmeridge Clay, Welton Lincs ..	246	2.139	.107	20.0
12	Kimmeridge Clay, Dover	570	0.387	.0455	8.5
13	Lower Lias, Micketon, Glos.......	700	1.120	.0803	13.9
14	Clay with Flints, Harpenden	10	0.577	.0294	19.6

NOTES

1. A grey coarse sand.
2. Pale grey fine sandy rock.
3. Coarse yellowish sand.
4. Fine yellowish sand.
5. Solid grey clay.
6. Solid dark green clay.
7. Close grey and red mottled clay.
8. Hard grey shale.
9, 10, 12. Hard grey clays from the coal pit shafts at Dover.
11. Hard grey clay.
13. Hard grey clay.
14. Reddish sandy brick earth.

It will be seen from a study of the above tables that under normal conditions the nitrogen-carbon ratio of the soil has a tendency to become narrower as the age of the organic material increases. The ratio, however, never becomes narrower nor ever equal to the ratio of the more common proteins contained in the humus producing materials.

(b) CARBON, NITROGEN AND PHOSPHORUS IN ILLINOIS SOILS

Before discussing the phosphorus-carbon and phosphorus-nitrogen ratios in the soil it seemed desirable to determine as closely as possible these ratios in fresh material out of which humus might be formed.

TABLE 12.—APPROXIMATE CARBON-PHOSPHORUS AND NITROGEN-PHOSPHORUS RATIOS IN THE MORE COMMON HUMUS PRODUCING MATERIALS

Kind of material	Carbon to 1 of phosphorus	Nitrogen to 1 of phosphorus
Corn stover	417	8.0
Oat straw	420	6.2
Wheat straw	525	6.2
Timothy hay	283	8.0
Clover hay	171	8.0
Cowpea hay	181	9.3
Alfalfa hay	186	11.1
Nuclein	3.7	1.4

The ratios in the more common humus producing materials calculated from the average of a number of analyses for nitrogen and phosphorus (68), will be found in Table 12. In the coarser material the phosphorus-carbon ratio varies from 1:417 to 1:525; the phosphorus-nitrogen ratio is more constant, being 1:6.2 and 1:8. In the hays the phosphorus-carbon ratio varies from 1:186 to 1:283, while again the phosphorus-nitrogen ratio is more constant, the variation being 1:11.1 to 1:8. In nuclein the ratios are 1:3.7 and 1:1.4 respectively.

In Table 13 will be found the phosphorus-carbon and phosphorus-nitrogen ratios obtained by calculation from the Minnesota Soil Studies. The phosphorus determinations which were reported as phosphoric anhydrid were first recalculated to the element basis. Both ratios, it will be observed, are very narrow.

In Table 14 will be found the phosphorus-carbon and phosphorus-nitrogen ratios in Illinois soils calculated from the data reported by Hopkins and Pettit (68). The average of 7 calculations of the gray silt loam on tight clay gave the phosphorus-carbon and phosphorus-nitrogen ratios as 1:42.6 and 1:13.8 respectively.

TABLE 13.—MINNESOTA SOIL STUDIES: CARBON-PHOSPHORUS AND NITROGEN-PHOSPHORUS RATIOS

Kind of material	Carbon to 1 of phosphorus	Nitrogen to 1 of phosphorus
Original soil	?	?
Cow manure	9.8	1.4
Clover	11.2	1.7
Meat scraps	9.7	2.2
Oat straw	38.2	1.8
Flour	22.0	2.2
Saw dust	37.0	0.24
Sugar	42.4	0.06

TABLE 14.—ILLINOIS SOILS: ORGANIC PHOSPHORUS; RATIOS OF CARBON TO PHOSPHORUS, NITROGEN TO PHOSPHORUS AND CARBON TO NITROGEN, FACTORS FOR CALCULATING THE ORGANIC PHOSPHORUS

Soil type No.	Number of analyses on which calculations are based	Organic phosphorus as per cent of total phosphorus	Ratios of		Factors for calculating the organic phosphorus from the organic carbon
			Carbon to 1 of organic phosphorus	Nitrogen to 1 of organic phosphorus	
330	7	24.4	142.	13.8	0.007012
426	9	34.4	132.	10.6	0.007570
526	8	29.5	185.	14.0	0.005393
626	5	13.9	298.	25.1	0.003348
726	4	38.1	133.	10.5	0.007491
1126	24	40.9	116.	9.9	0.008583
1026	9	44.9	125.	10.9	0.007988
Average	59	33.5	165.	13.5	0.006053
420	7	36.0	134.	10.3	0.007441
520	5	33.8	260.	12.0	0.003836
1120	11	46.2	90.	8.3	0.005907
1220	2	32.4	169.	15.2	0.002956
Average	25	37.1	163.	11.4	0.006113
1401	4	100.0	230.	19.6	0.004311
1401	(b) 5	100.0	338.	26.5	0.002956

(b) Subsoil (7"—40")

The ordinary brown silt loam soils, as an average of 59 determinations, gave the ratios of 1 :165.2 and 1 :13.5 respectively. The black clay loam soils, as an average of 25 calculations, gave the ratios of 1 :163 and 1 :11.4 respectively. The ratios in the surface peaty soil, assuming all the phosphorus to be in the organic state, are 1 :230 and 1 :19.6. The ratios in the subsoil of the peaty soil are somewhat wider, being 1 :338 and 1 :26.5 respectively.

(c) FACTORS FOR CALCULATING ORGANIC PHOSPHORUS

By means of the carbon-phosphorus ratios established as indicated above, it is possible to develop factors for calculating the amount of the organic phosphorus in the surface soil from the total organic carbon. For example, the carbon-phosphorus ratio, 1 :163, in the black clay loam soils means that for every part of organic phosphorus there are 163 parts of carbon or for each part of organic carbon there are 0.006113 parts of organic phosphorus. Hence by multiplying the amount of organic carbon by the latter number the amount of organic phosphorus may be obtained.

The factors as developed will be found in the last column of Table 14. It is hoped that they will be of value in drawing broad general conclusions regarding organic phosphorus of the soil from a number of analyses. The variations in the various samples considered in any single type are too great to permit the utilization of the factors in isolated cases.

It will be observed that from 1/4 to 2/5 of the total phosphorus of the several soil types considered is in organic combination. These results indicate that a larger amount of phosphorus is in organic combination than the work of some American investigators would lead us to believe.

2. CHEMICAL

(a) ANALYTICAL RESULTS OF SOIL FROM ILLINOIS SOUTH EXPERIMENTAL FARM

A sample of soil for a study of the organic phosphorus, by the available methods for the determination of the organic phosphorus of the soil, was obtained from the Illinois South Experimental Farm. This soil is the ordinary brown silt loam soil of the corn belt.

The total potassium, carbon, nitrogen and phosphorus in the surface and subsoil were determined by the methods adopted by the Illinois Experiment Station. The results, expressed as pounds per two million pounds of dry soil, will be found in Table 15. The average potassium content of 36,700 pounds and 37,070 pounds in the surface and subsoil indicate a constant mineral composition; hence the calculation method may be safely applied for the determination of the organic phosphorus. The amount of organic phosphorus, the various ratios and the developed factor will be found in Table 16. It will be seen that 46 percent of the total phosphorus in this soil is in organic combination.

TABLE 15.—ANALYTICAL RESULTS OF SOIL FROM ILLINOIS SOUTH EXPERIMENTAL FARM: RESULTS EXPRESSED AS POUNDS IN TWO MILLION POUNDS OF DRY SOIL

Soil No.	Soil stratum	Potassium	Carbon	Nitrogen	Phosphorus*
1A	Surface	36280	41800	3760	938
1B	Surface	37120	42180	3844	901
Average	Surface	36700	41990	3802	919*
3A	Subsoil	36600	......	1735	702
3B	Subsoil	37540	......	1680	670
Average	Subsoil	37070	......	1708	686

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*Later inspection of the strip of land from which this sample was taken led to the conclusion that it may have been modified by a previous disturbance of the soil in putting in tile drainage; and a composite sample was subsequently collected at points a short distance from the tile drain which showed 985 pounds of phosphorus instead of 919 pounds. The possible influence of this difference should be kept in mind. Thus the percent of total phosphorus in organic form would be reduced from 46 percent to 43 percent.—C. G. Hopkins

TABLE 16.—ORGANIC PHOSPHORUS: RATIOS OF CARBON TO ORGANIC PHOSPHORUS, NITROGEN TO 1 ORGANIC PHOSPHORUS, CARBON TO NITROGEN IN SURFACE SOIL

Pounds of organic phosphorus in two million pounds of soil	Organic phosphorus as percent of total phosphorus	Ratios of			Factor for calculating the organic phosphorus from organic carbon
		Nitrogen to 1 organic phosphorus	Carbon to 1 nitrogen	Carbon to 1 organic phosphorus	
423	46.0	9.0	11.1	99.2	0.01008

(b) PHOSPHORUS ASSOCIATED WITH THE *Matière Noire*

Of the two available methods for determining the organic phosphorus, the one, the determination of the phosphorus associated with the *matière noire* extracted from the soil by 4 percent ammonia, has given rise to some confusion. Grandeau (10) regarded the phosphorus extracted with the *matière noire* as being probably in organic combination. Eggertz (21), Nilson (79), Wiklund (25), Dumont (65), Ladd (43) and Snyder (41) also regarded it as organic in form. Pitsch (14) and Van Bemmelen (23) took the opposite view. Pitsch thought that part of the extracted phosphorus may have been derived from the inorganic phosphates of the soil. Van Bemmelen regarded the phosphorus precipitated with the *matière noire* as absorbed phosphorus. Quite recently Fraps (69) concluded that only 1/3 of the phosphorus extracted by ammonia was in organic combination, while still later Stoddart (80) concluded that only 1/5 of the extracted phosphorus was in organic combination. As a result of this conflicting evidence there is considerable confusion regarding the nature of the phosphorus extracted by ammonia. One cause of this confusion, no doubt, is the difficulty of getting rid of the suspended clay—ordinary filtration will not remove it. Obviously all of the phosphorus associated with the suspended clay should not be included with the organic phosphorus, altho part of it may be organic in form. Fraps removed the clay by precipitation with ammonium sulfate. There is no evidence, however, that this reagent does not also precipitate some organic matter either chemically or mechanically. Ammonium sulfate is used by physiological chemists to precipitate the proteins in order to make certain group separations, while some preliminary work here showed that complete saturation of the ammoniacal extract of the soil with ammonium sulfate, after the removal of the suspended clay, produced a heavier qualitative precipitate of organic matter than did the addition of hydrochloric acid. It would seem, therefore, that the evaporation method of Hampton and Mooers (77) is more desirable for the removal of the suspended clay. Unless otherwise stated the latter method was used for the removal of the suspended clay in all the work reported in this paper.

Owing to the conflicting evidence regarding the phosphorus associated with the extracted *matière noire,* it seemed desirable to do some work with this material other than the simple determination of the phosphorus.

The soil, without previous treatment with hydrochloric acid to remove the calcium, was extracted with 4 percent ammonia in the ratio of 1 part of soil to 50 parts of ammonia water for 36 hours, as in the usual humus determinations. The clay was removed by evaporation and the *matière noire* was obtained in quantity for study. Conditions here are such that the maximum quantity of inorganic phosphorus should be found in the ammoniacal extract since none has previously been removed by treatment with a mineral acid, as in the usual humus determinations.

The suspended clay removed by evaporation was analyzed for carbon and phosphorus with results as follows: Carbon 3.73 percent and 3.61 percent, or an average of 3.67 percent; phosphorus 0.118 percent and 0.109 percent, or an average of 0.113 percent. Since the carbon in the original soil was only 2.09 percent while the phosphorus was .046 percent, the relative increase of carbon and phosphorus in the suspended clay indicates undoubtedly the accumulation of organic matter with the "clay." It would appear probable that the grinding of the sample of soil, while preparing it for analysis, would convert the organic matter into an impalpable powder which would have a tendency to remain suspended in the liquid together with the fine clay particles when the soil was extracted with ammonia.

The amount of the *extracted matière noire* was determined It was then analyzed for carbon, nitrogen and phosphorus. The carbon was determined by the method suggested by Pettit and Schaub (59). The total nitrogen was determined by the regular Kjeldahl method; correction was then made for the absorbed ammoniacal nitrogen by determining the latter in a separate sample by distillation with magnesium oxid. The phosphorus was determined by igniting a sample of the *matière noire* and treating the ash with aqua regia; the silica was removed by evaporation and the phosphorus determined by the usual volumetric method. A confirmatory test made by determining phosphorus by fusion with sodium peroxid gave 0.835 percent and 0.815 percent phosphorus in the *matière noire,* while the method adopted gave 0.860 percent and 0.830 percent.

The results obtained expressed as pounds per two million pounds of soil are recorded in Table 17.

TABLE 17.—*Matière Noire*, CARBON, NITROGEN AND PHOSPHORUS IN THE *Matière Noire*; RESULTS EXPRESSED AS POUNDS PER TWO MILLION POUNDS OF DRY SOIL

(Soil not acid-extracted before treatment with ammonia)

Number	*Matière Noire*	Carbon in the *Matière Noire*	Nitrogen in the *Matière Noire*	Phosphorus in the *Matière Noire*
A	27600	10870	1642	233
B	28600	10850	1662	242
Average	28100	10860	1652	238

Phosphorus-nitrogen ratio = 1 :6.9
Nitrogen-carbon ratio=1 :6.6
Phosphorus-carbon ratio = 1 :45.6

The *matière noire* was now redissolved in dilute ammonia, an excess of 1 percent hydrochloric acid added, and set aside over night. The precipitate of organic matter was brought on to a filter paper which had previously been dried at 110°C and weighed. The precipitate was washed with 1 percent hydrochloric acid, dried at 100°C and weighed. The precipitated *matière noire* was obtained in quantity and analyzed for carbon, nitrogen and phosphorus. The results obtained are recorded in Table 18.

TABLE 18.—PRECIPITATED *Matière Noire*, CARBON, NITROGEN AND PHOSPHORUS IN PRECIPITATED *Matière Noire*: RESULTS EXPRESSED AS POUNDS PER TWO MILLION POUNDS OF DRY SOIL

(Soil not acid-extracted before treatment with ammonia)

Number	Precipitated *Matière Noire*	Carbon in precipitated *Matière Noire*	Nitrogen in precipitated *Matière Noire*	Phosphorus in precipitated *Matière Noire*
A	9174	4262	604	20
B	9203	4303	628	18
Average	9189	4282	616	19

Phosphorus-nitrogen ratio = 1 :32.4
Nitrogen-carbon ratio = 1 :7
Phosphorus-carbon ratio = 1 :225

The results recorded in Tables 17 and 18 are very significant, as can be more readily seen by glancing at Table 19, which summarizes the above data.

TABLE 19.—*Matière Noire*, CARBON, NITROGEN AND PHOSPHORUS PRECIPITATED FROM AMMONIACAL SOLUTION BY HYDROCHLORIC ACID: RESULTS EXPRESSED AS PERCENT OF TOTAL SOLUBLE IN AMMONIA

(Soil not acid-extracted before treatment with ammonia)

Matière Noire	Carbon	Nitrogen	Phosphorus
32.7	39.4	37.3	8.0

Of the total *matière noire* obtained, only 32.7 percent has been precipitated from the alkaline solution by hydrochloric acid. The portion remaining in solution does not consist of inorganic salts, as might be supposed, as is readily shown by the fact that only 39.4 percent of the carbon and 37.3 percent of the nitrogen has been precipitated. This shows conclusively that only about 1/3 of the dissolved organic matter has been precipitated.

Only 8.0 percent of the total soluble phosphorus, or 19 pounds out of 238 pounds, has been precipitated from alkaline solution by hydrochloric acid. Has the phosphorus remaining in solution in the mother liquor been derived from organic or inorganic sources? The fact that 60.6 percent of the carbon and 62.7 percent of the nitrogen also remain dissolved in the mother liquor would appear to be significant.

Having made a study of the *matière noire* obtained from the original soil it seemed desirable to investigate the *matière noire* obtained in the usual way after the soil had been extracted with 1 percent hydrochloric acid to remove the calcium and magnesium. It seemed reasonable to suppose that the acid extraction would remove also a considerable quantity, if not all, of the inorganic phosphorus, which may have previously passed into the ammonia solution.

As before, the amount of *matière noire* was determined and then extracted in quantity for the determination of carbon, nitrogen and phosphorus. The results obtained will be found in Table 20.

TABLE 20.—*Matière Noire*, CARBON, NITROGEN AND PHOSPHORUS IN THE *Matière Noire*: RESULTS EXPRESSED AS POUNDS PER TWO MILLION POUNDS OF DRY SOIL

(Soil acid-extracted before treatment with ammonia)

Number	*Matière Noire*	Carbon in the *Matière Noire*	Nitrogen in the *Matière Noire*	Phosphorus in the *Matière Noire*
A	60840	25860	2805	524
B	61660	25790	2885	508
Average	61250	25825	2845	516

Phosphorus-nitrogen ratio = 1 :5.5
Nitrogen-carbon ratio = 1 :9.1
Phosphorus-carbon ratio = 1 :50

The *matière noire* was redissolved in dilute ammonia and an excess of 1 percent hydrochloric acid added. The amount of the precipitate and the carbon, nitrogen and phosphorus in the precipitate were determined as before. The results obtained are recorded in Table 21.

TABLE 21.—PRECIPITATED *Matière Noire;* CARBON, NITROGEN AND PHOSPHORUS IN THE PRECIPITATED *Matière Noire:* RESULTS EXPRESSED AS POUNDS IN TWO MILLION POUNDS OF DRY SOIL

(Soil first acid-extracted before treatment with ammonia)

Number	Precipitated *Matière Noire*	Carbon in precipitated *Matière Noire*	Nitrogen in precipitated *Matière Noire*	Phosphorus in precipitated *Matière Noire*
A	30110	11410	1242	57
B	31140	11555	1198	56
Average	30625	11482	1220	56

Phosphorus-nitrogen ratio = 1.21.7
Nitrogen-carbon ratio = 1 :9.5
Phosphorus-carbon ratio = 1.205

Table 22 summarizes the results reported in Tables 20 and 21. Of the total dissolved *matière noire* only 50 percent was precipitated. Again the greater part of the carbon and nitrogen remain in the mother liquor. Only 44.5 percent of the carbon and 42.9 percent of the nitrogen were precipitated while but 8.7 percent of the phosphorus was precipitated.

TABLE 22.—*Matière Noire;* CARBON, NITROGEN AND PHOSPHORUS PRECIPITATED FROM AMMONIACAL SOLUTION BY HYDROCHLORIC ACID: RESULTS EXPRESSED AS PERCENT OF TOTAL SOLUBLE IN AMMONIA

(Soil first acid-extracted before treatment with ammonia)

Matière Noire	Carbon	Nitrogen	Phosphorus
50.0	44.5	42.9	8.7

Again, the question regarding the source of the phosphorus remaining in solution arises. It will be seen that 55.6 percent of the soluble carbon and 58.1 percent of the soluble nitrogen also remain in solution. Attention should be called to the fact that when the original soil was treated direct with ammonia, without previous extraction with hydrochloric acid, under conditions where the maximum amount of inorganic phosphorus should be dissolved, only 238 pounds of phosphorus per two million pounds of soil were obtained: yet, after the soil had been treated with hydrochloric acid to remove the calcium, under conditions where the minimum amount of inorganic phosphorus would be dissolved by ammonia, 516 pounds of phosphorus per two million pounds of soil were obtained. The difference between these two numbers, 278 pounds, unquestionably represents phosphorus which must have been derived from organic sources. Now, since only 55 pounds of phosphorus is precipitated with the *matière noire* by hydrochloric acid, it would appear that the organic phosphorus associated with the precipitated *matière noire* is only a very small part of the organic phosphorus present in the soil.

Schmoeger (39) has demonstrated that the organic phosphorus compounds of the soil are decomposed by heating under pressure. It would appear probable, therefore, that the simple evaporation of the ammoniacal solution on the water bath in the preparation of the *matière noire* in quantity for analysis would cause a decomposition of the phosphorus compounds; hence when the *matière noire* is redissolved and precipitated by hydrochloric acid, less phosphorus would be obtained in the precipitate than would be the case if the material had not been heated. This idea was confirmed by experimental evidence, as is shown in Table 23. The precipitated *matière noire* obtained from the original soil, which had not been extracted with hydrochloric acid, showed 19 pounds of phosphorus per two million pounds of soil. A portion of the ammoniacal extract of this soil was freed from clay by Frap's method; an aliquot part of the extract was then neutralized with hydrochloric acid: the precipitate obtained showed 68 pounds of phosphorus per two million pounds of soil, or over three times as much as did the precipitate obtained from the evaporated material.

TABLE 23.—PHOSPHORUS IN PRECIPITATED *Matière Noire:* RESULTS EXPRESSED AS POUNDS PER TWO MILLION POUNDS OF DRY SOIL

Number	Soil not acid-extracted		Soil acid-extracted		
	Phosphorus in heated *Matière Noire*	Phosphorus in unheated *Matière Noire*	Phosphorus in heated *Matière Noire*	Phosphorus in unheated *Matière Noire*	Phosphorus in barium precipitate
A	20	61	56	133	133
B	18	77	57	164	138
Average	19	69	56	149	135

The acid-extracted soil gave similar results: the precipitated *matière noire* which had been subjected to heat gave only 55 pounds of phosphorus per two million pounds of soil, while the precipitated *matière noire* which had not been subjected to heat gave 149 pounds, or nearly three times as much. The latter result was again confirmed. When the ammoniacal extract, freed from clay by precipitation with ammonium sulfate, is treated with barium chlorid, the organic matter is quantitatively precipitated, as is indicated by the decolorizing of the supernatent liquid and by the fact that evaporation of the filtrate and ignition of the residue gives only a very faint charring. But unfortunately the barium chlorid also precipitates the inorganic phosphorus as barium phosphate under these conditions, and when the liquid is rendered acid it becomes colored, showing that organic matter as well as inorganic phosphorus has been dissolved. However, the precipitate was separated by filtration, washed with hydrochloric acid until free from barium and the phosphorus determined. This phosphorus must have been derived from organic sources. The results are recorded in the last column of Table 23 and compare very well with those previously obtained.

According to Schmoeger, extraction of the soil for 24 hours with 12 percent cold hydrochloric acid removes all of the inorganic phosphorus readily soluble in dilute acids. Would not such treatment also remove any inorganic phosphorus readily soluble in dilute alkali? It would certainly seem that the subsequent extraction with dilute ammonia of the acid-extracted residue ought to dissolve only organic phosphorus. This idea was confirmed by experimental evidence, and thus additional information regarding the nature of the ammonia-soluble phosphorus was obtained.

Two samples of 10 grams each of the soil under consideration were extracted for 24 hours with 100 c.c of 12 percent cold hydrochloric acid, and then filtered and washed with hot water until the filtrate was free from chlorids. One of the samples was then extracted with 4 percent ammonia for 36 hours in the usual way and the amount of ammonia-soluble phosphorus determined: the second sample was again extracted with 12 percent cold hydrochloric acid for 36 hours and the amount of soluble phosphorus determined. Both experiments were duplicated. The dilute ammonia extracted 540 and 570 pounds of phosphorus, or an average of 555 pounds of phosphorus per two million pounds of soil which had previously been extracted with cold 12 percent hydrochloric acid, while a second extraction with cold 12 percent hydrochloric acid yielded only 94 and 96 pounds, or an average of 95 pounds of phosphorus per two million pounds of soil.

It would seem reasonable to suppose that both extractions of the soil with cold 12 percent hydrochloric acid removed some organic phosphorus since Berthelot and André (31) have demonstrated that organic matter of the soil is somewhat soluble in this reagent.

It would also seem very *unreasonable* to suppose that dilute ammonia possessed as great a solvent power for inorganic phosphorus as does 12 percent cold hydrochloric acid. But assuming, for the sake of argument, that only inorganic phosphorus is extracted by the hydrochloric acid and that dilute ammonia has as great a solvent power for inorganic phosphorus as the hydrochloric acid, the above experiments seem to demonstrate that at least 460 pounds of phosphorus (555-95) of the ammonia-soluble phosphorus has been derived from organic sources and that at least 83 percent of the ammonia-soluble phosphorus has been derived from organic sources.

(c) ORGANIC PHOSPHORUS BY SCHMOEGER'S METHOD

The second method for determining the organic phosphorus is the one proposed by Schmoeger. Eggert, Nilson, Tacke and others have shown that simple ignition increased the solubility of the phosphorus in cold hydrochloric acid. The increased solubility of the phosphorus was believed to be due to the destruction of the organic phosphorus compounds. Therefore the amount of phosphorus in the original soil soluble in cold hydrochloric acid, subtracted from the amount in the ignited soil soluble in cold hydrochloric acid of the same strength, was regarded as having been derived from the organic phosphorus compounds. This assumption was confirmed by Schmoeger by hydrolyzing the soil under pressure at a temperature of 140°-160°C. This treatment of the soil decomposed the organic phosphorus compounds so that the organic phosphorus was rendered soluble in cold hydrochloric acid. The difference, therefore, between the amount of phosphorus extracted from the original soil by cold hydrochloric acid and the amount extracted from the soil which had been hydrolized gave the amount of organic phosphorus. Schmoeger found that, as a rule, concordant results were obtained by the two methods altho in certain cases slightly higher results were obtained by the latter method.

It was decided to determine the organic phosphorus by both of the above methods. Thus, 10 grams of the original soil was treated with 100 c.c. of 12 percent hydrochloric acid and digested in the cold with an occasional shaking for 24 hours. A second sample of 10 grams was ignited and then extracted with 12 percent cold hydrochloric acid in a similar manner. At the end of 24 hours the extract was diluted with water and separated by filtration. The residue was washed with cold water until the filtrate was free from chlorides: the filtrate was then made up to 500 c.c. and 100 c.c. used for the phosphorus determination. The results recorded in Table 24 show that there are 271 pounds of phosphorus in the original soil soluble in 12 percent cold hydrochloric acid, while there are 814 pounds in the ignited soil soluble in the same reagent. These results show, therefore, that there are 543 pounds of organic phosphorus in two million pounds of the surface soil.

Another sample of 10 grams of the soil was treated with acidulated water and heated in an autoclave for 12 hours at a temperature of 140°-145°C. The sample was then digested for 24 hours with cold hydrochloric acid, filtered and the filtrate made up to 500 c.c. An average of two determinations show that 878 pounds of phosphorus were obtained. This would indicate that there were 607 pounds of organic phosphorus in two million pounds of the surface soil. Slightly higher results for organic phosphorus are thus obtained by the autoclave method they are but it is probably more nearly correct since it is difficult to conceive how the treatment in the autoclave would render any inorganic phosphorus soluble which would not be rendered soluble by ignition, while the work of Leavitt and LeClerc (81, 82) would indicate that ignition might render some of the organic phosphorus insoluble in cold hydrochloric acid of any strength.

The calculation method shows that 423 pounds of phosphorus per two million of the surface soil are in organic combination: the ammoniacal extraction method shows 504 pounds of organic phosphorus and the ignition method shows 543 pounds, while Schmoeger's method shows that there are 607 pounds of organic phosphorus. The calculation method is therefore very conservative in nature and it can be safely stated that at least that much phosphorus is in organic combination. Table 26 gives the summarized results of the organic phosphorus obtained by the several methods.

TABLE 24.—PHOSPHORUS SOLUBLE IN TWELVE PERCENT HYDROCHLORIC ACID: RESULTS EXPRESSED AS POUNDS IN TWO MILLION POUNDS OF SOIL

Number	Original soil	Ignited soil	Organic phosphorus
A	266	819	
B	276	809	
Average	271	814	543

TABLE 25.—PHOSPHORUS SOLUBLE IN TWELVE PERCENT HYDROCHLORIC ACID: RESULTS EXPRESSED AS POUNDS IN TWO MILLION POUNDS OF SOIL

Number	Original soil	Evaporated soil	Organic phosphorus
A	266	876	
B	276	880	
Average	271	878	607

TABLE 26.—TOTAL PHOSPHORUS AND ORGANIC PHOSPHORUS BY SEVERAL METHODS

	Organic phosphorus by calculation		Organic phosphorus by solution in dilute ammonia		Organic phosphorus by ignition		Organic phosphorus by evaporation (Schmoeger)	
Total phosphorus	Pounds per two million pounds of soil	Percent of total	Pounds per two million pounds of soil	Percent of total	Pounds per two million pounds of soil	Percent of total	Pounds per two million pounds of soil	Percent of total
919	423	46	504	55	543	60	607	66

CONCLUSIONS

1. The phosphorus-nitrogen ratio in the surface soil of the brown silt loam soils is 1:13.5 while the same ratio in the black clay loam soils is 1:11.4.

2. Under normal conditions the nitrogen-carbon ratio of the soil has a tendency to become narrower as the age of the organic material increases: the ratio, however, never becomes narrower or even equal to the ratio of the more common proteins contained in the humus producing materials.

3. The nitrogen-carbon ratios of the ordinary brown silt loam soils of Illinois are 1:12.1, 1:11.5 and 1:8.9 in the surface, subsurface, and subsoil respectively.

The ratios in the black clay loam soils are 1:11.7, 1:11.9 and 1:9 in the surface, subsurface, and subsoil respectively.

4. The phosphorus-carbon ratio in the surface soil of the brown silt loam is 1:165.2 while the ratio in the surface soil of the black clay loam soils is 1:163.6.

5. The calculation method for determining organic phosphorus is very conservative in character and can be relied upon in drawing broad general conclusions.

6. The evaporation on the water bath of the ammoniacal solution in the preparation of the *matière noire* in quantity for analysis, causes a hydrolysis of the organic phosphorus compounds.

7. The determination of the phosphorus associated with the precipitated *matière noire* is not a quantitative method for the determination of the total organic phosphorus of the soil. It should be regarded only as a good qualitative evidence of the existence of organic phosphorus in the soil.

8. The contention of Fraps that "There is no evidence that the phosphoric acid in the filtrate is in organic combination" and that "It is probably derived from the iron and aluminium phosphates" is entirely untenable.

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NOTE

Robert Stewart was born in American Fork, Utah, August 16, 1877. He secured his common school education in the public schools of Utah. In the fall of 1896 he entered the preparatory department of the Agricultural College of Utah. He graduated from this institution in June, 1902, with the degree of Bachelor of Science. He immediately received an appointment as assistant chemist in the Utah Experiment Station. While holding this position, during the years 1902-03, 1903-04, he took graduate student work in the college. During the school year 1904-05 he was a member of the Graduate School of the University of Chicago, where he studied chemistry under the direction of Doctor Nef. In 1905 he was appointed assistant professor of chemistry in the Utah college and while holding this position, during the years 1905-06, 1906-07, 1907-08, he continued his graduate student work. During the summer of 1906 he was a member of the Graduate School of Agriculture held at the University of Illinois. In June, 1908, he was appointed professor of chemistry in the Utah college and was granted a leave of absence to carry on graduate work at the University of Illinois.

He is the senior author of Bulletin 103, "Milling Qualities of Utah Wheat," and Bulletin 106, "A Study of the Influence of Irrigation Waters upon the Movement and Production of Nitrates in the Soil," which has been accepted for publication by the Utah Experiment Station.

During the school year 1908-09 he held a fellowship in agronomy in the University of Illinois. He is a member of the Illinois chapter of Sigma Xi and also a charter member of the Illinois chapter of the American Society of Agronomy.

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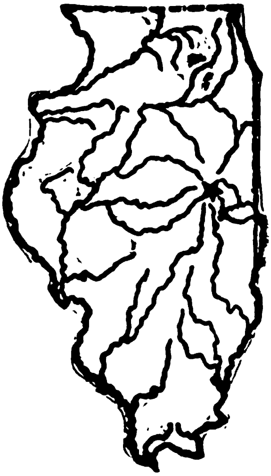
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 146

ALFALFA HAY *VS.* TIMOTHY HAY AND ALFALFA HAY *VS.* BRAN FOR DAIRY COWS

By **WILBER J. FRASER** and **CASSIUS C. HAYDEN**



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SUMMARY OF BULLETIN No. 146

1. A ration containing 10 pounds of alfalfa hay produces 17 percent more milk than the same ration when timothy is substituted for the alfalfa. Pages 132 to 137

2. A ration containing 8 pounds of alfalfa hay proves to be equal to the same ration when bran is substituted for the alfalfa hay. Pages 138 to 144

NOTE—Bulletin No. 145, entitled Quantitative Relationships of Carbon, Phosphorus, and Nitrogen in Soils, is of a technical nature and consequently the issue was limited; but anyone desiring a copy may secure it on application to the Agricultural Experiment Station, Urbana, Illinois

ALFALFA HAY *VS.* TIMOTHY HAY
AND
ALFALFA HAY *VS.* BRAN FOR DAIRY COWS

BY **WILBER J. FRASER**, CHIEF IN DAIRY HUSBANDRY, AND
CASSIUS C. HAYDEN, FIRST ASSISTANT IN DAIRY HUSBANDRY

ALFALFA HAY *VS.* TIMOTHY

Two conditions exist in this State, in the feeding of dairy cows, which operate against the economic production of milk. The first is that large amounts of timothy hay are produced on dairy farms and fed to dairy cows, tho all authorities agree that it is of little value for this purpose, and the second is that while feeding this hay, dairymen must purchase and feed large quantities of expensive concentrates in order to supply the protein lacking in the timothy. Legumes not only give larger yields per acre than timothy, but are also of far greater value, ton for ton, as feed for dairy cows, because they can be made to supply a large part, or all of the protein furnished by the high-priced concentrates usually purchased, and at a great reduction in cost.

Because of these conditions, the demonstration here reported was planned to show the relative value of alfalfa and timothy hay in the ordinary ration for dairy cows. A dairy herd in the northern part of the State was selected for this work. It was kept on the farm and cared for by the owner,—Mr. Charles Gilkerson, of McHenry County.

PLAN OF THE DEMONSTRATION

Sixteen cows were divided into two lots of eight each, a lot standing on either side of the barn. The plan was not to compare the two lots, but to compare two feeding periods in the same lot, using one lot as a check against the other. The cows in Lot 1 had calved shortly before or during the preliminary feeding, but before the actual test began, while those in Lot 2 had been in milk longer.

(See Table 1.) This variation in time of calving of the cows in the two lots really made no difference in the final comparison. The table also shows that some cows were not in milk at the beginning. However, this does not affect the final results, as all the cows were in milk during the two periods compared.

TABLE 1.—DATES OF CALVING

Lot 1		Lot 2	
No. Cow	Date of calving	No. Cow	Date of calving
1	December 5	9	September 24
2	September 14	10	November 8
3	September 8	11	August 15
4	January 3	12	September 3
5	December 25	13	October 25
6	November 16	14	August 31
7	December 6	15	September 19
8	December 15	16	September 30

The records of feed and milk were kept for twenty-five weeks, from November 26 to May 20. The first 3 weeks were taken for a preliminary period, the next 18 weeks were divided into two feeding periods of 9 weeks each, and this was followed by a subsequent period of 4 weeks. The feed was weighed to each lot, but not to each individual cow. Thruout the entire demonstration the basal ration consisted of a grain mixture of 2½ pounds of corn meal to 1 pound of wheat bran, and shredded corn stover. The rations are shown in tabular form below.

AVERAGE RATION

	Lot 1 First Period		Second Period
Mixed grain,	13 Lb.		12 Lb.
Corn stover,	10 Lb.		10 Lb.
Timothy hay,	10 Lb.	Alfalfa hay,	10 Lb.
Nutritive ratio*	1 : 10.2		1 : 6.6
	Lot 2		
Mixed grain,	13 Lb.		12 Lb.
Corn stover,	10 Lb.		10 Lb.
Alfalfa hay,	10 Lb.	Timothy hay,	10 Lb.
Nutritive ratio*	1 : 6.6		1 : 10.2

During the preliminary period, besides the basal ration both lots received mixed alsike and timothy hay. An average of 13 pounds of the mixed grain was fed per cow, daily, during the first feeding period of 9 weeks, and 12 pounds daily during the second feeding period of 9 weeks. The last week of the first period the grain was raised to 14 pounds. The corn stover was fed at the rate of 10 pounds per cow, daily. The above part of the ration was the same for both lots. After the 3 weeks' preliminary period, the hay was changed to that which was to be fed during the first feeding period, Lot 1 receiving 10 pounds of timothy hay, and Lot 2, 10 pounds of alfalfa hay per cow. At the end of the first feeding period the timothy and alfalfa hay were reversed on both lots, and the second feeding period began, one week being taken to make the change of feed. In other words, during each of the two periods both lots were fed the same, with the exception that alfalfa hay was fed to one lot, and an equal amount of timothy to the other, making a direct comparison between alfalfa and timothy hay, when fed with the other feeds mentioned.

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*A nutritive ratio of 1 to 10.2 means that the ration contains 1 pound of digestible protein to 10.2 pounds of digestible carbohydrates plus the fat multiplied by 2¼.

During the subsequent period of four weeks, all of the cows were fed alfalfa hay and pastured on green rye for a short time each day. May 9, the grain was reduced to 8 pounds per cow for both lots.

TABLE 2.—LOT 1. POUNDS OF MILK PRODUCED PER COW PER WEEK

Preliminary Period, - Mixed Hay									
No. Cow	1	2	3	4	5	6	7	8	Average
No. Week									
1	*203*	199	202	*240*	*220*	198	*250*	*218*	216
2	*202*	206	204	*240*	*220*	194	*250*	*218*	217
3	203	205	207	*240*	*220*	189	252	*218*	217
First Feeding Period,—Timothy									
4	198	193	208	*240*	*215*	180	248	219	213
5	192	192	206	*238*	*210*	177	235	198	206
6	175	158	179	*236*	221	177	235	187	191
Period Taken for Comparison									
7	**169**	**172**	**180**	**235**	**199**	**174**	**193**	**198**	**190**
8	**170**	**181**	**181**	**228**	**205**	**166**	**188**	**178**	**187**
9	**170**	**181**	**187**	**222**	**204**	**168**	**197**	**187**	**190**
10	**172**	**181**	**189**	**210**	**206**	**173**	**203**	**176**	**189**
11	**174**	**181**	**190**	**213**	**189**	**173**	**214**	**157**	**186**
12	**179**	**185**	**190**	**230**	**194**	**168**	**213**	**173**	**192**
Total	**1034**	**1081**	**1117**	**1338**	**1197**	**1022**	**1208**	**1069**	**1134**
Second Feeding Period,—Alfalfa									
13	187	189	190	231	203	160	212	181	194
14	193	205	200	232	207	173	225	199	204
15	199	212	201	247	216	181	234	203	212
Period Taken for Comparison									
16	**203**	**205**	**202**	**243**	**221**	**184**	**242**	**187**	**211**
17	**207**	**210**	**201**	**244**	**225**	**176**	**243**	**181**	**211**
18	**199**	**208**	**194**	**239**	**221**	**170**	**240**	**187**	**207**
19	**202**	**200**	**196**	**235**	**202**	**177**	**235**	**202**	**206**
20	**200**	**197**	**195**	**240**	**205**	**174**	**230**	**202**	**205**
21	**201**	**208**	**189**	**229**	**229**	**175**	**225**	**200**	**207**
Total	**1212**	**1228**	**1177**	**1430**	**1303**	**1056**	**1415**	**1159**	**1247**
Subsequent Period,—Alfalfa and Green Rye									
22	205	212	195	230	155	181	237	210	203
23	207	221	186	240	165	190	247	208	208
24	204	211	174	250	182	195	238	205	207
25	206	213	175	252	192	191	242	188	207

TABLE 3.—LOT 2. POUNDS OF MILK PRODUCED PER COW PER WEEK

No Cow	9	10	11	12	13	14	15	16	Average
Preliminary Period,—Mixed Hay									
No. Week									
1	150	196	111	153	179	144	189	180	167
2	151	198	121	155	176	150	195	185	166
3	155	204	122	148	179	156	206	190	170
First Feeding Period,—Alfalfa									
4	165	213	124	159	185	162	206	191	176
5	162	215	128	151	182	160	206	197	175
6	159	218	123	148	181	152	199	188	171
Period Taken for Comparison									
7	**157**	**219**	**127**	**154**	**182**	**164**	**204**	**193**	**175**
8	**166**	**215**	**127**	**156**	**184**	**163**	**207**	**193**	**176**
9	**169**	**224**	**130**	**154**	**182**	**170**	**211**	**195**	**179**
10	**146**	**225**	**125**	**145**	**184**	**166**	**214**	**200**	**176**
11	**158**	**221**	**130**	**144**	**183**	**170**	**217**	**202**	**178**
12	**161**	**221**	**136**	**149**	**180**	**169**	**225**	**207**	**181**
Total	**957**	**1325**	**775**	**902**	**1095**	**1002**	**1278**	**1190**	**1065**
Second Feeding Period,—Timothy									
13	158	208	131	150	174	167	209	195	174
14	148	185	116	139	156	151	190	172	157
15	140	168	112	136	144	149	184	163	149
Period Taken for Comparison									
16	**137**	**167**	**105**	**140**	**153**	**153**	**185**	**164**	**150**
17	**134**	**164**	**80**	**115**	**148**	**157**	**186**	**162**	**143**
18	**136**	**164**	**59**	**116**	**148**	**154**	**172**	**160**	**137**
19	**131**	**149**	**87**	**117**	**143**	**148**	**157**	**152**	**136**
20	**130**	**158**	**83**	**116**	**134**	**149**	**142**	**154**	**133**
21	**124**	**153**	**76**	**118**	**141**	**143**	**133**	**152**	**130**
Total	**792**	**955**	**490**	**722**	**867**	**904**	**975**	**944**	**829**
Subsequent Period,—Alfalfa and Green Rye									
22	136	169	88	129	153	154	115	120	133
23	160	189	98	123	178	166	174	188	159
24	177	189	114	143	182	180	166	200	169
25	164	190	121	133	173	175	159	196	164

Tables 2 and 3 show the amount of milk produced per week by each cow, and the average production of the eight cows in each lot for the twenty-five weeks during which the records were kept. The four divisions of the demonstration are shown in each table by the sub-headings. The first change in the hay, from alsike and timothy to alfalfa on one lot, and to timothy on the other, was made abruptly at the beginning of the first feeding period. The second change in hay was made gradually during the first week of the second feeding period. The tables show that in each case it required about three weeks for the cows to adjust themselves to the change in hay. Consequently, only the last six weeks of each period were taken for the comparison between the hays. The portion of the tables set in bold-faced type represent these periods. All of the remaining portions of these tables are used only in the construction of Charts 1 and 2.

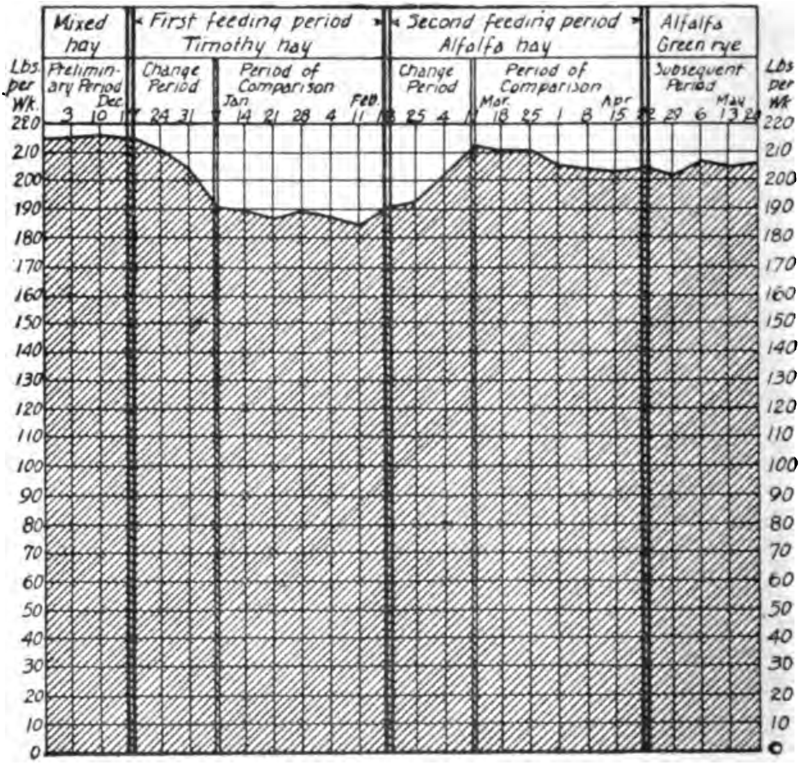
In Lot 1, some of the cows were not in milk at the beginning of the preliminary feeding. Their production has been estimated from their later records and the production of the other cows, so that the average may be given during this time. The averages for these first six weeks are used only in the construction of Charts 1 and 2, **and not in the actual comparisons between the different kinds of hay.** The amounts of milk which were estimated are in italics.

DESCRIPTION OF HOW THE CHARTS ARE MADE

The average amount of milk produced per cow per week during the different periods, and the effect of the different feeds on milk production in each lot, are shown more plainly by Charts 1 and 2. Each space from the bottom to the top represents 10 pounds of milk produced, and each space from left to right represents one week's time. The distance from the heavy base line at the bottom, which stands for zero, to the undulating line extending across the page at the top of the shaded portion, represents the average amount of milk produced per cow per week. For example, at the beginning of the preliminary feeding, the cows in Lot 1 were producing an average of 216 pounds of milk per week, as is shown by the undulating line starting about midway between 210 and 220 pounds. For the next two weeks, the production was practically the same, and the line runs almost horizontally. The next three weeks there was a gradual decline in production, until at the close of the week ending January 7 the average production of the cows was only 191 pounds, and the undulating line drops nearly to the intersection of the line representing 190 pounds, and in this manner follows the average production of Lot 1 across the chart.

A study of Chart 1 and Table 2 shows, at a glance, that as soon as the hay was changed on Lot 1, December 17, from mixed alsike clover and timothy to timothy, there was a sudden drop in the milk flow of about 25 pounds per cow in three weeks, and that this flow remained down to a little below the 190-pound line until the close of the first period, when the hay was changed from timothy to alfalfa. As soon as this change was made there was a rapid rise, during the next three weeks, or up to the close of the alfalfa period. When the cows were turned on green rye, April 22, this

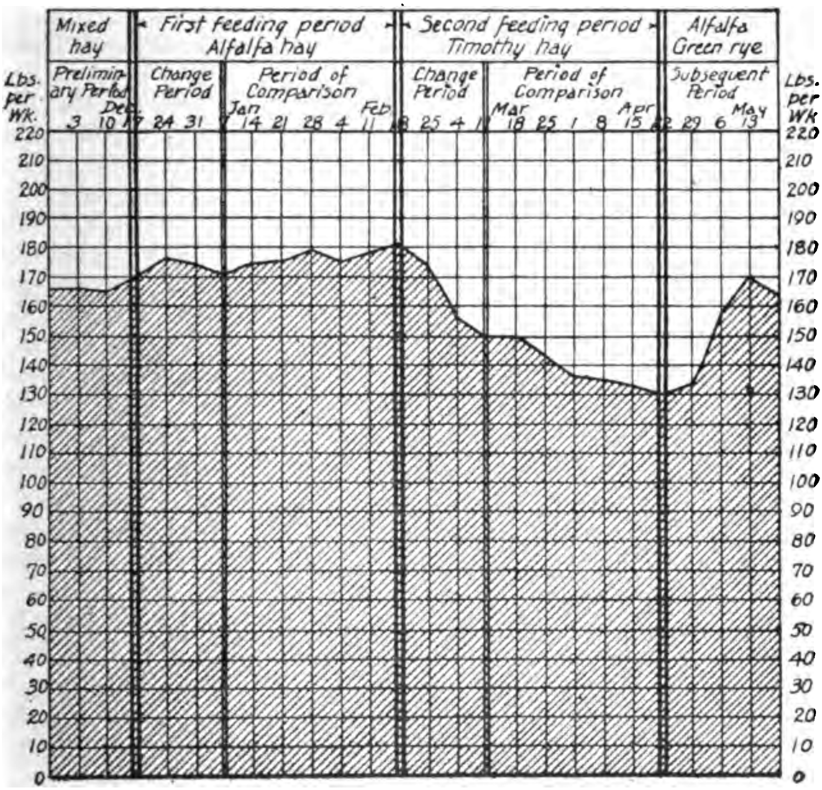
CHART 1.—LOT 1. AVERAGE MILK PRODUCED PER COW PER WEEK



flow was still maintained, on rye and alfalfa, for the next four weeks.

A study of Chart 2 and Table 3, shows that when the hay was changed on Lot 2, December 17, from mixed clover and timothy to alfalfa, there was a slight increase in the milk flow, which continued during the alfalfa period. When the hay was changed from alfalfa to timothy, there was a rapid decrease during the next three weeks of 32 pounds of milk per cow, and during the remaining six weeks of the timothy hay period the average flow continued to drop until there was a further decrease of 19 pounds. In other words, the milk flow dropped 52 pounds per cow during the nine weeks on the ration containing timothy hay. When the hay was changed from timothy to alfalfa, April 22, and the cows turned onto green rye, it is interesting to note how rapidly the milk production increased to the same point as at the beginning of the preliminary period, 25 weeks previously, notwithstanding the fact that the grain had been reduced from 12 to 8 pounds.

CHART 2.—LOT 2. AVERAGE MILK PRODUCED PER COW PER WEEK



The average amount of milk produced per cow in Lot 1 for the six weeks' timothy period was 1134 pounds, and that for the six weeks' alfalfa period was 1247 pounds,—a difference of 113 pounds per cow, or 9.1 percent in favor of the alfalfa hay. The average amount of milk produced by Lot 2 for the six weeks' alfalfa period was 1065 pounds, and that for the six weeks' timothy period was 829 pounds,—a difference of 236 pounds per cow, or 28.4 percent in favor of alfalfa hay. Taking the average for the two lots, we find that they produced 17.7 percent more milk while fed alfalfa hay than while fed timothy. This great difference in favor of alfalfa over timothy was not only true of the lots, but of each individual cow in the lots, which adds greatly to the evidence in favor of alfalfa hay.

Assuming that the above difference would continue for the winter feeding period of six months, the total difference in milk production for a herd of 16 cows would be 12,100 pounds of milk, which, at $1.30 per hundred pounds, the price received, would be worth $157.30, which equals $9.83 per cow; $157.30 is equal to six percent interest on the money invested in sixteen cows at $163 each.

The total amount of milk produced by both lots for the six weeks during which they were fed alfalfa was 18,496 pounds and for the six weeks fed timothy it was 15,704 pounds. The difference in milk between these two periods was 2792 pounds, which is 834 pounds in favor of each ton of alfalfa over timothy. This total difference of 2792 pounds of milk, at $1.30 per hundred pounds, the price received, was worth $36.30. Three and thirty-four hundredths tons of hay were fed during this time, therefore in this test, alfalfa hay was worth $10.86 per ton more than timothy. The average yields per acre obtained in Illinois are approximately four tons of alfalfa hay and one and one-half tons of timothy. If timothy hay is worth $10 per ton, one acre of alfalfa is worth $68.44 more than an acre of timothy, when figured on the above basis.

The value of the alfalfa will vary with the price received for the milk, and for this reason the following table of values has been constructed:

TABLE 4.—SHOWS THE GREATER FEEDING VALUE OF ALFALFA HAY THAN OF TIMOTHY, WITH MILK AT DIFFERENT PRICES

Milk per 100 pounds	Value of alfalfa, per ton, **above timothy**.	Value of alfalfa, per acre, **above timothy**, when timothy is worth $10 per ton. (Alfalfa 4 T. per acre; timothy 1½ T. per acre.)
$1.00	$ 8.36	$58.44
1.10	9.19	61.76
1.20	10.03	65.12
1.30	10.86	68.44
1.40	11.70	71.80
1.50	12.54	75.16
1.60	13.38	78.52
1.70	14.21	81.84
1.80	15.06	85.24
1.90	15.88	88.52
2.00	16.72	91.88

It must be borne in mind that the above figures can be applied to alfalfa only when fed with the feeds used in this test, or with other similar feeds.

CONDITION OF COWS

Besides the greater returns in milk, the condition of the cows counts for much. At the end of each period, the cows which were fed alfalfa hay were in much better condition than those fed timothy. The timothy, altho of good quality, was not palatable, and the cows receiving it lost in flesh, their hair was rough, and they were in poor condition, generally. A number of them were more or less "off feed" at different times. Such was not the case with the same cows while being fed alfalfa. They had better appetites and ate their corn stover more readily than when receiving timothy hay. If the effect is so great in so short a time, it is easy to see why many of the dairy cows in Illinois come out of the winter in poor condition and have a small milk account to their credit.

This shows that it is easily possible to get much better results from alfalfa hay than from hay made of the grasses. What is true of alfalfa also applies largely to the other legumes. Besides making a better and more palatable roughage, legume hay will furnish all or a large part of the protein commonly supplied in purchased feeds. To show this more conclusively, the following demonstration was carried out at the Agricultural Experiment Station:

ALFALFA HAY *VS.* BRAN

The plan of this demonstration was to feed equal amounts, by weight, of alfalfa hay and bran, with a basal ration made up of farm products only. Six cows in the Station herd (all that were available at the time for the purpose) were selected and divided into two lots of three each. While this is too small a number from which to draw general conclusions, some importance must be attached to the results. The test began December 3 and continued until April 27. This time was divided into two periods of nine and one-half weeks each.

RATIONS

The same basal ration, consisting of the following, was fed to both lots:

Clover hay,	6 pounds
Corn silage,	30 pounds
Corn meal,	6 pounds

For the first period, Lot 1 was given, in addition to the above, all the choice alfalfa hay they would eat up clean, and Lot 2 was given an equal amount of bran, by weight. For the second period, the alfalfa and bran were reversed on the two lots. Each cow consumed nearly 8 pounds of alfalfa hay or bran, daily. The complete rations were as follows:

	Ration 1		Ration 2
Clover hay,	6 pounds		6 pounds
Corn silage,	30 pounds		30 pounds
Corn meal,	6 pounds		6 pounds
Alfalfa hay,	8 pounds	Bran,	8 pounds
Nutritive ratio,	1:7		1:6.9

Both lots were kept as nearly as possible under the same conditions, except as to feed. Cow No. 24, in Lot 1, got loose during the night and ate a large amount of grain, which caused her to go "off feed" and produce at least 100 pounds less milk than she otherwise would have done. The results of the test are shown in the following tables and charts:

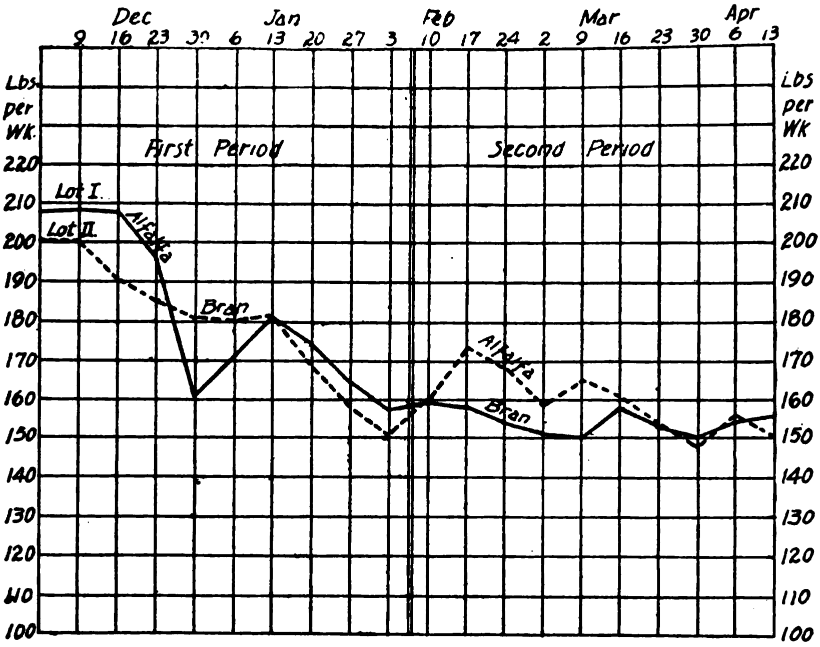
TABLE 5.—POUNDS OF MILK PRODUCED PER COW PER WEEK AND AVERAGE FOR EACH LOT

	Lot 1				Lot 2			
	Alfalfa				Bran			
Week ending	Cows			Average	Cows			Average
	No. 24	No. 37	No. 26		No. 12	No. 54	No. 13	
Dec. 9	206	244	176	209	213	144	244	200
" 16	205	238	182	208	203	142	230	192
" 23	198	224	168	197	201	135	223	186
" 30	96	221	169	162	192	132	220	181
Jan. 6	133	213	170	174	194	129	219	180
" 13	162	218	162	181	194	126	225	182
" 20	159	207	155	173	185	122	200	169
" 27	159	191	142	164	176	116	181	157
Feb. 3	158	181	136	158	177	113	171	153
" 7	90	109	87	95	99	66	104	89
Total	1571	2046	1547	1721	·1834	1225	2017	1689
	Bran				Alfalfa			
Feb. 10	69	83	63	65	76	50	86	70
" 17	155	176	145	158	186	128	219	174
" 24	152	175	137	154	176	115	217	169
Mar. 2	148	172	134	151	171	110	199	160
" 9	146	171	135	151	176	108	211	165
" 16	154	179	141	158	176	107	201	161
" 23	149	173	137	153	166	109	188	154
" 30	149	171	131	150	162	106	176	148
Apr. 6	156	176	133	155	168	113	188	156
" 13	157	177	133	156	161	111	179	150
" 14	21	26	19	22	24	16	24	21
Total	1456	1679	1308	1478	1642	1063	1888	1528

Table 5 shows the pounds of milk produced by the individual cows for each week. A study of this table shows that in Lot 1, which received the alfalfa hay during the first period, there was a gradual decrease in milk from the beginning to the close of the test, except in the case of cow No. 26, which increased temporarily when changed to the bran. In Lot 2 there was a marked increase of about 20 pounds of milk per cow in two weeks, when changed from bran to the alfalfa hay. This difference cannot be attributed to a difference in the protein of the ration, as in the previous test, because the protein was practically the same in both rations.

Chart 3 shows graphically the average production of the two lots. Each space from bottom to top represents ten pounds of milk and each space from left to right represents one week. It will be noted that Lot 1, which received the alfalfa hay first, was

CHART 3 —AVERAGE POUNDS OF MILK PRODUCED PER COW PER WEEK



producing, at the beginning, about 8 pounds of milk per cow per week more than Lot 2. This difference continued until the fourth week, when the line representing Lot 1 drops below that representing Lot 2. This was due to cow No. 24 being off feed, as previously stated. Had this not occurred, the line representing Lot 1 would have continued above the line for Lot 2. At the close of the first period, when the alfalfa hay and bran were changed, the line representing the production of Lot 2 immediately rises above that for Lot 1, and continues above until toward the close of the test. The fact that these lines follow each other closely across the chart indicates that there was little difference in the effect of bran and alfalfa hay.

A study of Table 6 shows that the production of fat has not exactly followed the production of milk. In changing from alfalfa hay to bran, (Lot 1) there was in every case an increase in the amount of fat, tho the amount of milk decreased. In changing from bran to alfalfa hay, (Lot 2) there was a slight increase in the amount of fat, but not in proportion to the increase in milk. This is shown graphically in Charts 3 and 4.

TABLE 6.—PRODUCTION OF FAT PER COW PER WEEK, AND AVERAGE

	Lot 1				Lot 2			
	Alfalfa				Bran			
Week ending	Cows			Average	Cows			Average
	No. 24	No. 37	No. 26		No. 1.	No. 54	No. 13	
Dec. 9	9.08	10.23	7.81	9.04	8.92	6.60	7.33	7.61
" 16	8.60	10.00	7.83	8.81	8.52	6.24	6.67	7.14
" 23	8.71	9.66	7.38	8.58	8.45	6.62	6.69	7.25
" 30	4.11	9.51	7.45	7.02	8.07	6.86	6.37	7.10
Jan. 6	5.62	8.93	7.92	7.49	8.35	6.07	6.36	6.93
" 13	7.30	9.38	7.60	8.09	8.32	6.18	6.74	7.08
" 20	7.01	9.12	7.14	7.76	8.13	5.83	6.38	6.78
" 27	6.82	8.23	6.68	7.24	8.03	5.56	5.60	6.40
Feb. 3	6.61	7.95	6.40	6.99	7.34	5.41	5.63	6.13
" 7	3.98	4.56	4.01	4.18	4.13	3 28	3.10	3.50
Total	67.84	87.57	70.22	75.20	78.26	58.65	60.87	65.92
	Bran				Alfalfa			
Feb. 10	3.02	3.50	2.91	3.14	3.18	2.51	2.58	2.76
" 17	7.30	8.41	6.68	7.47	7.42	5.41	6.80	6.54
" 24	6.69	7.74	6.71	7.05	7.58	5.28	6.09	6.32
Mar. 2	6.82	7.98	6.35	7.05	7.00	5.15	5.76	5.97
" 9	6.73	7.16	6.75	6.88	7.04	4.98	6.00	6.00
" 16	7.17	7.53	6.77	7.16	7.04	5.25	5.63	5.97
" 23	6.55	7.45	6.58	6.86	6.65	4.99	5.46	5.70
" 30	6.87	7.02	6.30	6.73	6.24	5.04	5.28	5.52
Apr. 6	6.85	7.58	7.03	7.15	6.38	5.17	5.62	5.72
" 13	7.07	7.43	6.90	7 13	6.02	5.34	5.01	5.46
" 14	.93	1.13	1.01	1.02	.94	.76	.72	8.1
Total	66.00	72.96	63.99	67.64	65.49	49.88	54.95	56.77

CHART 4.—AVERAGE POUNDS OF FAT PRODUCED PER COW PER WEEK

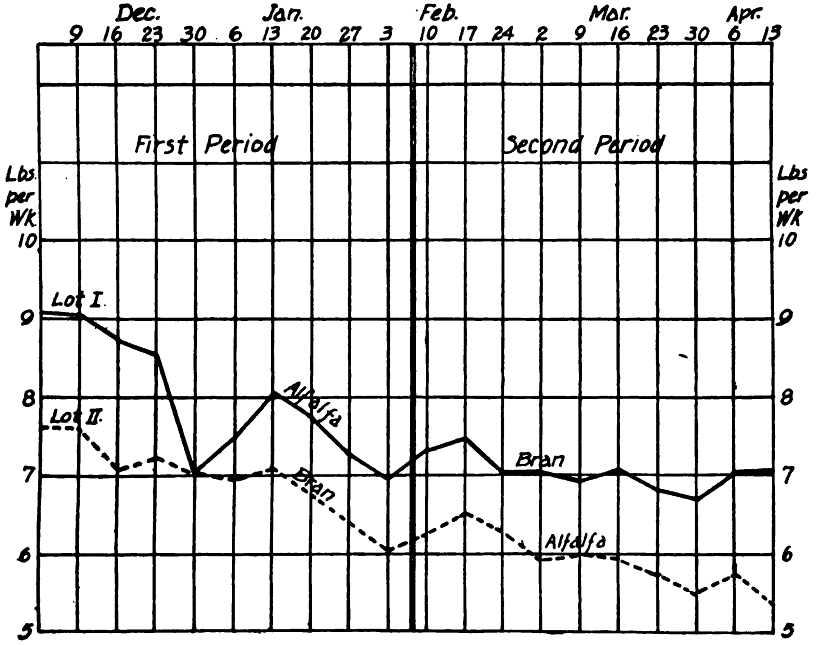


TABLE 7.—TOTAL POUNDS OF MILK AND FAT PRODUCED AND FOOD CONSUMED FOR EACH PERIOD; TOTALS FOR THE ALFALFA HAY PERIODS AND THE BRAN PERIODS

Lot 1	Milk	Fat	Corn meal	Silage	Clover hay	Bran	Alfalfa hay
First period, alfalfa	5161.8	225.63	1186	5916	1112.2		1546
Second period, bran,	4445.8	202.93	1206	6030	1170.0	1608	
Lot 2							
First period, bran,	5068.7	197.80	1206	6030	1136.0	1561	
Second period, alfalfa,	4591.9	170.32	1206	6030	1161.5		1608
Totals							
Alfalfa periods,	9753.7	395.95	2392	11946	2273.7		3154
Bran periods,	9514.5	400.73	2412	12060	2306.0	3169	
Difference in favor of alfalfa hay,	239.2	-4.78	-20	-114	-32.3	-15	

Table 7 shows that while fed alfalfa hay the cows produced 239.2 pounds more milk, and 4.78 pounds less butter fat than while fed bran. They also consumed twenty pounds less corn meal, 114 pounds less silage, 32 pounds less clover hay, and 15 pounds less alfalfa hay than bran, because one cow was off feed. This difference in the amount of feed is small and amounts to little more than one day's ration for the lot, and could not account for more than 75 pounds of milk. On the same feed basis, therefore, the cows produced 314 pounds more milk and 3.5 pounds less butter fat while on the ration containing the alfalfa hay. This shows alfalfa equal to or a little better than bran for milk production, under the conditions which are the same as those existing on most dairy farms.

This result does not quite agree with the findings of the Pennsylvania, Tennessee, and some other stations, which found alfalfa meal and alfalfa hay slightly inferior to bran. It is safe to say that, when alfalfa can be grown on the farm, it is the best substitute for bran in feeding dairy cattle.

It should be noted that in this demonstration only choice alfalfa hay was fed. The cows receiving the alfalfa hay were in better physical condition at the end of each period than were those receiving bran.

These two demonstrations indicate that alfalfa hay will not only supply a palatable roughage and a large amount of protein, but also that alfalfa keeps the animals in better physical condition than such rations as timothy hay with grains high in protein. Like the other legumes, it takes large amounts of nitrogen from the air and causes it to be fixed in the soil. For these reasons we urge that every dairyman make a strenuous effort to grow at least a small piece of alfalfa. For methods of growing, see Illinois Agricultural Experiment Station Bulletin No. 76.

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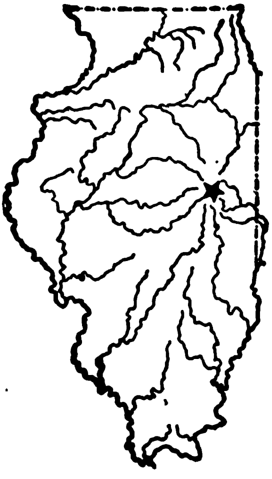
UNIVERSITY OF ILLINOIS
Agricultural Experiment Station

BULLETIN NO. 146

ALFALFA HAY *VS.* TIMOTHY HAY
AND
ALFALFA HAY *VS.* BRAN
FOR DAIRY COWS

(SECOND EDITION, NOVEMBER, 1912)

BY WILBER J. FRASER AND CASSIUS C. HAYDEN



URBANA, ILLINOIS, JUNE, 1910

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The Station.

SUMMARY OF BULLETIN No. 146

1. A ration containing 10 pounds of alfalfa hay produces 17 percent more milk than the same ration when timothy is substituted for the alfalfa. Pages 132 to 137

2. A ration containing 8 pounds of alfalfa hay proves to be equal to the same ration when bran is substituted for the alfalfa hay. Pages 138 to 144

ALFALFA HAY *VS.* TIMOTHY HAY

AND

ALFALFA HAY *VS.* BRAN FOR DAIRY COWS

BY WILBER J. FRASER, CHIEF IN DAIRY HUSBANDRY, AND
CASSIUS C. HAYDEN, FIRST ASSISTANT IN DAIRY HUSBANDRY

ALFALFA HAY *VS.* TIMOTHY

Two conditions exist in this state in the feeding of dairy cows, which operate against the economic production of milk. The first is that large amounts of timothy hay are produced on dairy farms and fed to dairy cows, tho all authorities agree that it is of little value for this purpose; and the second is that while feeding this hay, dairymen must purchase and feed large quantities of expensive concentrates in order to supply the protein lacking in the timothy. Legumes not only give larger yields per acre than timothy, but are also of far greater value, ton for ton, as feed for dairy cows, because they can be made to supply a large part, or all, of the protein furnished by the high-priced concentrates usually purchased, and at a great reduction in cost.

Because of these conditions, the demonstration here reported was planned to show the relative value of alfalfa and timothy hay in the ordinary ration for dairy cows. A dairy herd in the northern part of the state was selected for this work. It was kept on the farm and cared for by the owner, Mr. Charles Gilkerson, of McHenry county.

PLAN OF THE DEMONSTRATION

Sixteen cows were divided into two lots of eight each, a lot standing on either side of the barn. The plan was not to compare the two lots, but to compare two feeding periods in the same lot, using one lot as a check against the other. The cows in Lot 1 had calved shortly before or during the preliminary feeding but before the actual test began, while those in Lot 2 had been in milk longer.

(See Table 1.) This variation in time of calving of the cows in the two lots really made no difference in the final comparison. The table also shows that some cows were not in milk at the beginning. However, this does not affect the final results, as all the cows were in milk during the two periods compared.

TABLE 1.—DATES OF CALVING

Lot 1		Lot 2	
No. cow	Date of calving	No. cow	Date of calving
1	December 5	9	September 24
2	September 14	10	November 8
3	September 8	11	August 15
4	January 3	12	September 3
5	December 25	13	October 25
6	November 16	14	August 31
7	December 6	15	September 19
8	December 15	16	September 30

The records of feed and milk were kept for twenty-five weeks, from November 26 to May 20. The first 3 weeks were taken for a preliminary period, the next 18 weeks were divided into two feeding periods of 9 weeks each, and this was followed by a subsequent period of 4 weeks. The feed was weighed to each lot, but not to each individual cow. Thruout the entire demonstration the basal ration consisted of a grain mixture of 2½ pounds of corn meal to 1 pound of wheat bran, and shredded corn stover. The rations are shown in tabular form below.

AVERAGE RATION

	First Period	Second Period
	Lot 1	
Mixed grain	13 lb.	12 lb.
Corn stover	10 lb.	10 lb.
Timothy hay	10 lb.	Alfalfa hay, 10 lb.
Nutritive ratio*	1 : 10.2	1 : 6.6
	Lot 2	
Mixed grain	13 lb.	12 lb.
Corn stover	10 lb.	10 lb.
Alfalfa hay	10 lb.	Timothy hay, 10 lb.
Nutritive ratio*	1 : 6.6	1 : 10.2

During the preliminary period, besides the basal ration both lots received mixed alsike and timothy hay. An average of 13 pounds of the mixed grain was fed per cow, daily, during the first feeding period of 9 weeks, and 12 pounds daily during the second feeding period of 9 weeks. The last week of the first period the grain was raised to 14 pounds. The corn stover was fed at the rate of 10 pounds per cow, daily. The above part of the ration was the same for both lots. After the 3 weeks' preliminary period, the hay was changed to that which was to be fed during the first feeding period, Lot 1 receiving 10 pounds of timothy hay, and Lot 2, 10 pounds of alfalfa hay per cow. At the end of the first feeding period the timothy and alfalfa hay were reversed on both lots, and the second feeding period began, one week being taken to make the change of feed. In other words, during each of the two periods both lots were fed the same, with the exception that alfalfa hay was fed to one lot, and an equal amount of timothy to the other, making a direct comparison between alfalfa and timothy hay when fed with the other feeds mentioned.

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*A nutritive ratio of 1 to 10.2 means that the ration contains 1 pound of digestible protein to 10.2 pounds of digestible carbohydrates plus the fat multiplied by 2¼.

During the subsequent period of four weeks, all of the cows were fed alfalfa hay and pastured on green rye for a short time each day. May 9 the grain was reduced to 8 pounds per cow for both lots.

Table 2.—LOT 1. POUNDS OF MILK PRODUCED PER COW PER WEEK

Preliminary Period: Mixed Hay									
No. cow	1	2	3	4	5	6	7	8	Average
No. week									
1	*203*	199	202	*240*	*220*	198	*250*	*218*	216
2	*202*	206	204	*240*	*220*	194	*250*	*218*	217
3	203	205	207	*240*	*220*	189	252	*218*	217
First Feeding Period: Timothy									
4	198	193	208	*240*	*215*	180	248	219	213
5	192	192	206	*238*	*210*	177	235	198	206
6	175	158	179	*236*	221	177	235	187	191
Period Taken for Comparison									
7	**169**	**172**	**180**	**235**	**199**	**174**	**193**	**198**	**190**
8	**170**	**181**	**181**	**228**	**205**	**166**	**188**	**178**	**187**
9	**170**	**181**	**187**	**222**	**204**	**168**	**197**	**187**	**190**
10	**172**	**181**	**189**	**210**	**206**	**173**	**203**	**176**	**189**
11	**174**	**181**	**190**	**213**	**189**	**173**	**214**	**157**	**186**
12	**179**	**185**	**190**	**230**	**194**	**168**	**213**	**173**	**192**
Total	**1034**	**1081**	**1117**	**1338**	**1197**	**1022**	**1208**	**1069**	**1134**
Second Feeding: Alfalfa									
13	187	189	190	231	203	160	212	181	194
14	193	205	200	232	207	173	225	199	204
15	199	212	201	247	216	181	234	203	212
Period Taken for Comparison									
16	**203**	**205**	**202**	**243**	**221**	**184**	**242**	**187**	**211**
17	**207**	**210**	**201**	**244**	**225**	**176**	**243**	**181**	**211**
18	**199**	**208**	**194**	**239**	**221**	**170**	**240**	**187**	**207**
19	**202**	**200**	**196**	**235**	**202**	**177**	**235**	**202**	**206**
20	**200**	**197**	**195**	**240**	**205**	**174**	**230**	**202**	**205**
21	**201**	**208**	**189**	**229**	**229**	**175**	**225**	**200**	**207**
Total	**1212**	**1228**	**1177**	**1430**	**1303**	**1056**	**1415**	**1159**	**1247**
Subsequent Period: Alfalfa and Green Rye									
22	205	212	195	230	155	181	237	210	203
23	207	221	186	240	165	190	247	208	208
24	204	211	174	250	182	195	238	205	207
25	206	213	175	252	192	191	242	188	207

TABLE 3.—LOT 2. POUNDS OF MILK PRODUCED PER COW PER WEEK

No. cow	9	10	11	12	13	14	15	16	Average
Preliminary Period: Mixed Hay									
No. week									
1	150	196	111	153	179	144	189	180	167
2	151	198	121	155	176	150	195	185	166
3	155	204	122	148	179	156	206	190	170
First Feeding Period: Alfalfa									
4	165	213	124	159	185	162	206	191	176
5	162	215	128	151	182	160	206	197	175
6	158	218	123	148	181	152	199	188	171
Period Taken for Comparison									
7	**157**	**219**	**127**	**154**	**182**	**164**	**204**	**193**	**175**
8	**166**	**215**	**127**	**156**	**184**	**163**	**207**	**193**	**176**
9	**169**	**224**	**130**	**154**	**182**	**170**	**211**	**195**	**179**
10	**146**	**225**	**125**	**145**	**184**	**166**	**214**	**200**	**176**
11	**158**	**221**	**130**	**144**	**183**	**170**	**217**	**202**	**178**
12	**161**	**221**	**136**	**149**	**180**	**169**	**225**	**207**	**181**
Total	**957**	**1325**	**775**	**902**	**1095**	**1002**	**1278**	**190**	**1065**
Second Feeding Period: Timothy									
13	158	208	131	150	174	167	209	195	174
14	148	185	116	139	156	151	190	172	157
15	140	168	112	136	144	149	184	163	149
Period Taken for Comparison									
16	**137**	**167**	**105**	**140**	**153**	**153**	**185**	**164**	**150**
17	**134**	**164**	**80**	**115**	**148**	**157**	**186**	**162**	**143**
18	**136**	**164**	**59**	**116**	**148**	**154**	**172**	**160**	**137**
19	**131**	**149**	**87**	**117**	**143**	**148**	**157**	**152**	**136**
20	**130**	**158**	**83**	**116**	**134**	**149**	**142**	**154**	**133**
21	**124**	**153**	**76**	**118**	**141**	**143**	**133**	**152**	**130**
Total	**792**	**955**	**490**	**722**	**867**	**904**	**975**	**944**	**829**
Subsequent Period: Alfalfa and Green Rye									
22	136	169	88	129	153	154	115	120	133
23	160	189	98	123	178	166	174	188	159
24	177	189	114	143	182	180	166	200	169
25	164	190	121	133	173	175	159	196	164

Tables 2 and 3 show the amount of milk produced per week by each cow, and the average production of the eight cows in each lot for the twenty-five weeks during which the records were kept. The four divisions of the demonstration are shown in each table by the sub-headings. The first change in the hay, from alsike and timothy to alfalfa on one lot, and to timothy on the other, was made abruptly at the beginning of the first feeding period. The second change in hay was made gradually during the first week of the second feeding period. The tables show that in each case it required about three weeks for the cows to adjust themselves to the change in hay. Consequently, only the last six weeks of each period were taken for the comparison between the hays. The portion of the tables set in bold-face type represent these periods. All the remaining portions of these tables are used only in the construction of Charts 1 and 2.

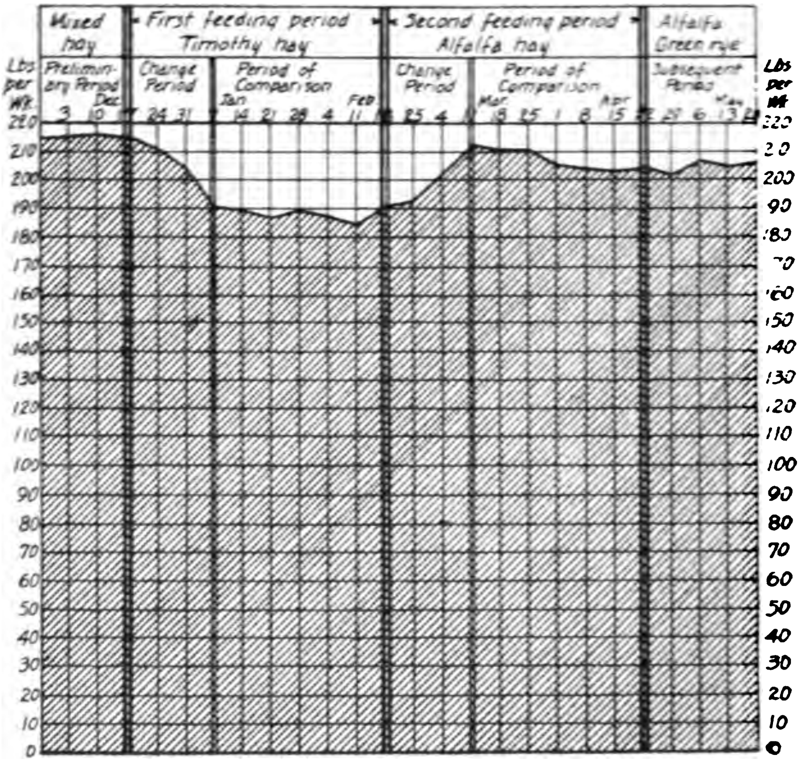
In Lot 1 some of the cows were not in milk at the beginning of the preliminary feeding. Their production has been estimated from their later records and the production of the other cows, so that the average may be given during this time. The averages for these first six weeks are used only in the construction of Charts 1 and 2, **and not in the actual comparisons between the different kind of hay.** The amounts of milk which were estimated are in italics.

DESCRIPTION OF HOW THE CHARTS ARE MADE

The average amount of milk produced per cow per week during the different periods, and the effect of the different feeds on milk production in each lot, are shown more plainly by Charts 1 and 2. Each space from the bottom to the top represents 10 pounds of milk produced, and each space from left to right represents one week's time. The distance from the heavy base line at the bottom, which stands for zero, to the undulating line extending across the page at the top of the shaded portion, represents the average amount of milk produced per cow per week. For example, at the beginning of the preliminary feeding, the cows in Lot 1 were producing an average of 216 pounds of milk per week, as is shown by the undulating line starting about midway between 210 and 220 pounds. For the next two weeks, the production was practically the same, and the line runs almost horizontally. The next three weeks there was a gradual decline in production, until at the close of the week ending January 7 the average production of the cows was only 191 pounds, and the undulating line drops nearly to the intersection of the line representing 190 pounds, and in this manner follows the average production of Lot 1 across the chart.

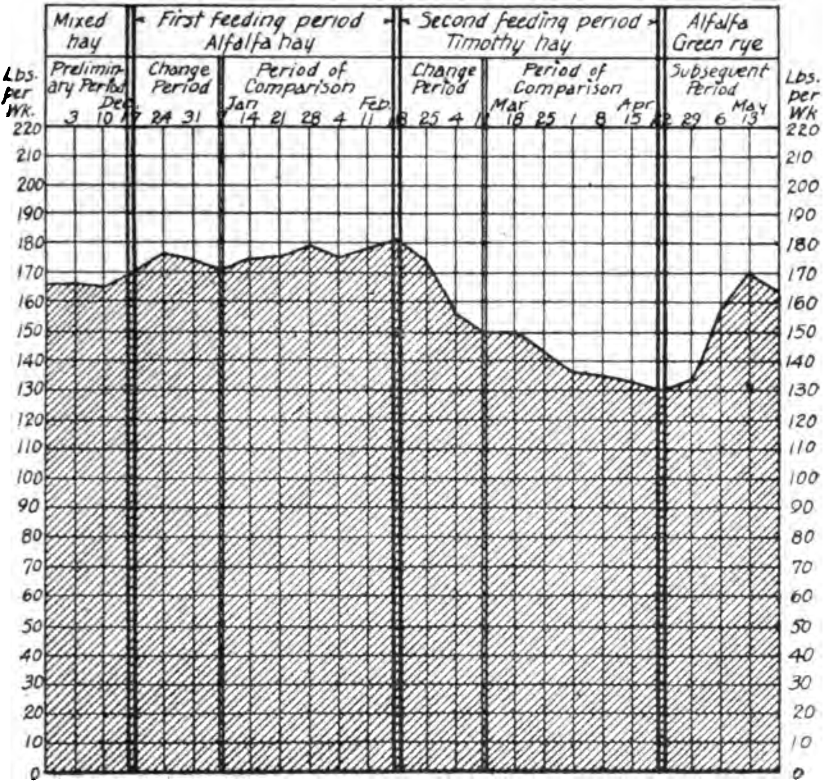
A study of Chart 1 and Table 2 shows at a glance that as soon as the hay was changed on Lot 1, December 17, from mixed alsike clover and timothy to timothy, there was a sudden drop in the milk flow of about 25 pounds per cow in three weeks, and that this flow remained down to a little below the 190-pound line until the close of the first period, when the hay was changed from timothy to alfalfa. As soon as this change was made there was a rapid rise, which continued during the next three weeks, followed by a gradual decrease up to the close of the alfalfa period. When the cows were turned on green rye, April 22, this flow was still maintained, on rye and alfalfa, for the next four weeks.

CHART 1.—LOT 1. AVERAGE MILK PRODUCED PER COW PER WEEK



A study of Chart 2 and Table 3 shows that when the hay was changed on Lot 2, December 17, from mixed clover and timothy to alfalfa, there was a slight increase in the milk flow, which continued during the alfalfa period. When the hay was changed from alfalfa to timothy, there was a rapid decrease during the next three weeks of 32 pounds of milk per cow, and during the remaining six weeks of the timothy hay period the average flow continued to drop until there was a further decrease of 19 pounds. In other words, the milk flow dropped 52 pounds per cow during the nine weeks on the ration containing timothy hay. When the hay was changed from timothy to alfalfa, April 22, and the cows turned onto green rye, it is interesting to note how rapidly the milk production increased to the same point as at the beginning of the preliminary period 25 weeks previous, notwithstanding the fact that the grain had been reduced from 12 to 8 pounds.

CHART 2.—LOT 2. AVERAGE MILK PRODUCED PER COW PER WEEK



The average amount of milk produced per cow in Lot 1 for the six weeks' timothy period was 1134 pounds, and that for the six weeks' alfalfa period was 1247 pounds,—a difference of 113 pounds per cow, or 9.1 percent in favor of the alfalfa hay. The average amount of milk produced by Lot 2 for the six weeks' alfalfa period was 1065 pounds, and that for the six weeks' timothy period was 829 pounds,—a difference of 236 pounds per cow, or 28.4 percent in favor of alfalfa hay. Taking the average for the two lots, we find that they produced 17.7 percent more milk while fed alfalfa hay than while fed timothy. This great difference in favor of alfalfa over timothy was not only true of the lots, but of each individual cow in the lots, which adds greatly to the evidence in favor of alfalfa hay.

Assuming that the above difference would continue for the winter feeding period of six months, the total difference in milk production for a herd of 16 cows would be 12,100 pounds of milk.

CHART 1.—LOT 1. AVERAGE MILK PRODUCED PER COW PER WEEK

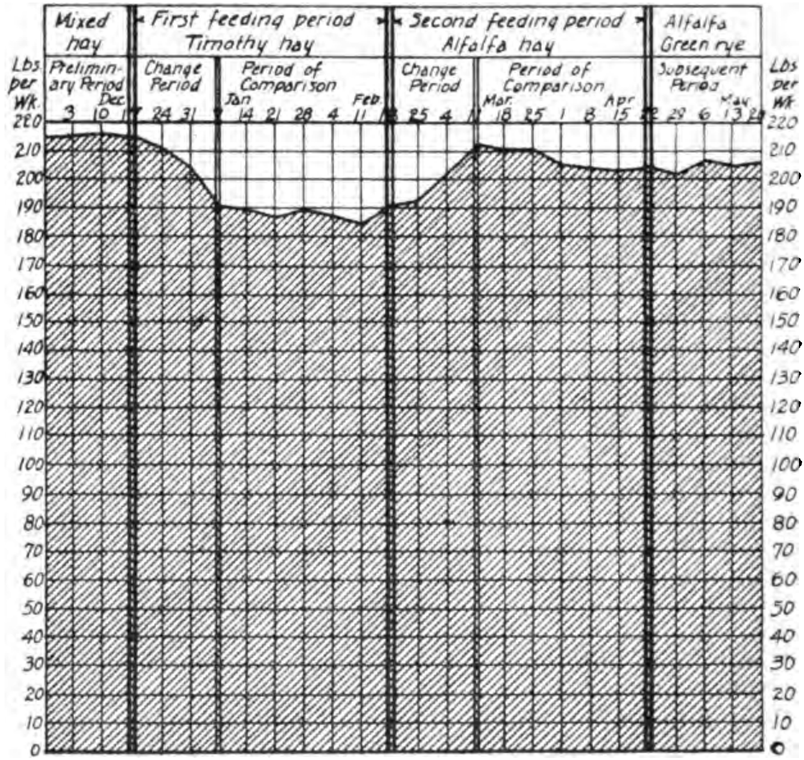


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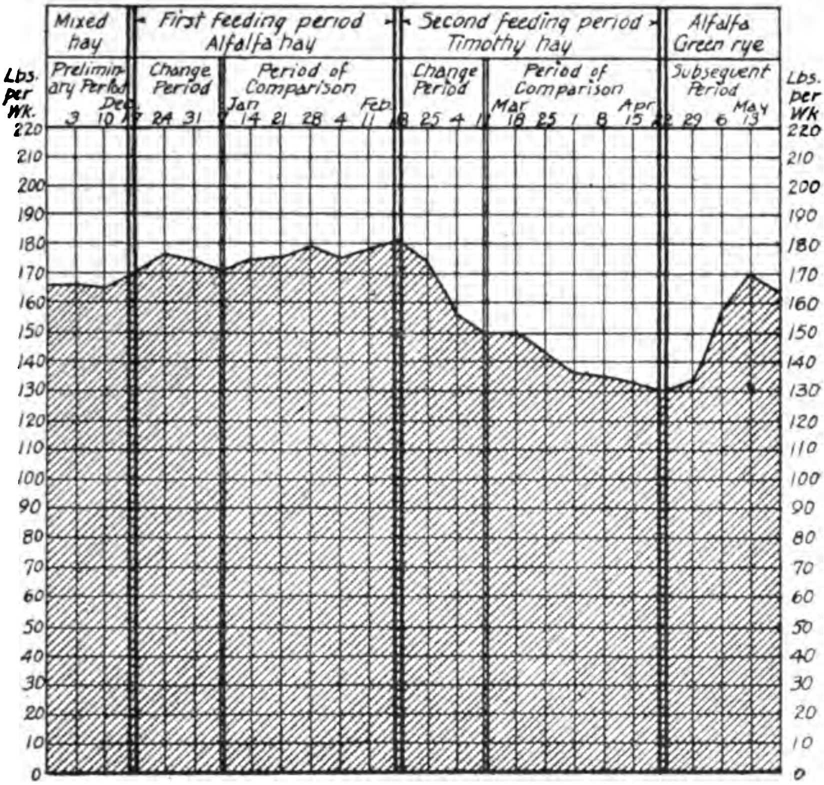
CHART 2.—LOT 2. AVERAGE MILK PRODUCED PER COW PER WEEK



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Assuming that the above difference would continue for the winter feeding period of six months, the total difference in milk production for a herd of 16 cows would be 12,100 pounds of milk.

which, at $1.30 per hundred pounds, the price received, would be worth $157.30, which equals $9.83 per cow; $157.30 is equal to six percent interest on the money invested in sixteen cows at $163 each.

The total amount of milk produced by both lots for the six weeks during which they were fed alfalfa was 18,496 pounds and for the six weeks fed timothy it was 15,704 pounds. The difference in milk between these two periods was 2792 pounds, which is 834 pounds in favor of each ton of alfalfa over timothy. This total difference of 2792 pounds of milk at $1.30 per hundred pounds, the price received, was worth $36.30. Three and thirty-four hundredths tons of hay were fed during this time; therefore in this test alfalfa hay was worth $10.86 per ton more than timothy. The average yields per acre obtained in Illinois are approximately four tons of alfalfa hay and one and one-half tons of timothy. If timothy hay is worth $10 per ton, one acre of alfalfa is worth $68.44 more than an acre of timothy when figured on the above basis.

The value of the alfalfa will vary with the price received for the milk, and for this reason the following table of values has been constructed:

TABLE 4.—SHOWS THE GREATER FEEDING VALUE OF ALFALFA HAY THAN OF TIMOTHY, WITH MILK AT DIFFERENT PRICES

Milk per 100 pounds	Value of alfalfa, per ton, **above timothy.**	Value of alfalfa, per acre, **above timothy,** when timothy is worth $10 per ton. (Alfalfa 4 T. per acre; timothy 1½T. per acre.)
$1.00	$ 8.36	$58.44
1.10	9.19	61.76
1.20	10.03	65.12
1.30	10.86	68.44
1.40	11.70	71.80
1.50	12.54	75.16
1.60	13.38	78.52
1.70	14.21	81.84
1.80	15.06	85.24
1.90	15.88	88.52
2.00	16.72	91.88

It must be borne in mind that the above figures can be applied to alfalfa only when fed with the feeds used in this test, or with other similar feeds.

CONDITION OF COWS

Besides the greater returns in milk, the condition of the cows counts for much. At the end of each period, the cows which were fed alfalfa hay were in much better condition than those fed timothy. The timothy, altho of good quality, was not palatable, and the cows receiving it lost in flesh, their hair was rough, and they were in poor condition generally. A number of them were more or less "off feed" at different times. Such was not the case with the same cows while being fed alfalfa. They had better appetites and ate their corn stover more readily than when receiving timothy hay. If the effect is so great in so short a time, it is easy to see why many of the dairy cows in Illinois come out of the winter in poor condition and have a small milk account to their credit.

This shows that it is easily possible to get much better results from alfalfa hay than from hay made of the grasses. What is true of alfalfa also applies largely to the other legumes. Besides making a better and more palatable roughage, legume hay will furnish all or a large part of the protein commonly supplied in purchased feeds. To show this more conclusively, the following demonstration was carried out at the Agricultural Experiment Station:

ALFALFA HAY *VS.* BRAN

The plan of this demonstration was to feed equal amounts, by weight, of alfalfa hay and bran, with a basal ration made up of farm products only. Six cows in the Station herd (all that were available at the time for the purpose) were selected and divided into two lots of three each. While this is too small a number from which to draw general conclusions, some importance must be attached to the results. The test began December 3 and continued until April 27. This time was divided into two periods of nine and one-half weeks each.

RATIONS

The same basal ration, consisting of the following, was fed to both lots:

Clover hay	**6**	**pounds**
Corn silage	**30**	**"**
Corn meal	**6**	**"**

For the first period, the cows in Lot 1 were given, in addition to the above, all the choice alfalfa hay they would eat up clean, and those in Lot 2 were given an equal amount of bran, by weight. For the second period, the alfalfa and bran were reversed on the two lots. Each cow consumed nearly 8 pounds of alfalfa hay or bran, daily. The complete rations were as follows:

	Ration 1		**Ration 2**
Clover hay	**6 pounds**		**6 pounds**
Corn silage	**30 "**		**30 "**
Corn meal	**6 "**		**6 "**
Alfalfa hay	**8 "**	**Bran,**	**8 "**
Nutritive ratio	**1:7**		**1:6.9**

Both lots were kept as nearly as possible under the same conditions, except as to feed. Cow No. 24, in Lot 1, got loose during the night and ate a large amount of grain, which caused her to go "off feed" and produce at least 100 pounds less milk than she otherwise would have done. The results of the test are shown in the following tables and charts:

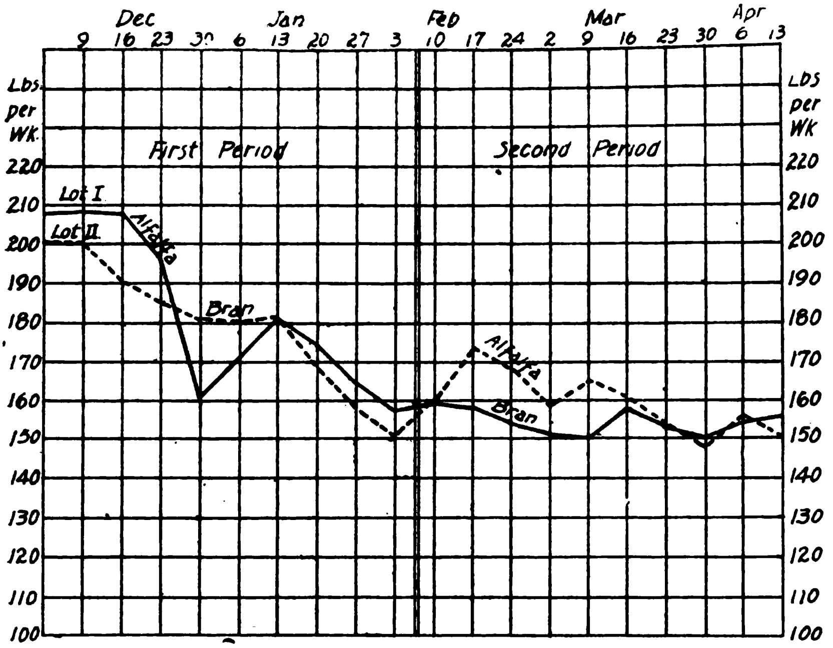
TABLE 5.—POUNDS OF MILK PRODUCED PER COW PER WEEK AND AVERAGE FOR EACH LOT

	Lot 1				Lot 2			
	Alfalfa				Bran			
	Cows				Cows			
Week ending	No. 24	No. 37	No. 26	Average	No. 12	No. 54	No. 13	Average
Dec. 9	206	244	176	209	213	144	244	200
" 16	205	238	182	208	203	142	230	192
" 23	198	224	168	197	201	135	223	186
" 30	96	221	169	162	192	132	220	181
Jan. 6	138	213	170	174	194	129	219	180
" 13	162	218	162	181	194	126	225	182
" 20	159	207	155	173	185	122	200	169
" 27	159	191	142	164	176	116	181	157
Feb. 3	158	181	136	158	177	113	171	153
" 7	90	109	87	95	99	66	104	89
Total	1571	2046	1547	1721	1834	1225	2017	1689
	Bran				Alfalfa			
Feb. 10	69	83	63	65	76	50	86	70
" 17	155	176	145	158	186	118	219	174
" 24	152	175	137	154	176	115	217	169
Mar. 2	148	172	134	151	171	110	199	160
" 9	146	171	135	151	176	108	211	165
" 16	154	179	141	158	176	107	201	161
" 23	149	173	137	153	166	109	188	154
" 30	149	171	131	150	162	106	176	148
Apr. 6	156	176	133	155	168	113	188	156
" 13	157	177	133	156	161	111	179	150
" 14	21	26	19	22	24	16	24	21
Total	1456	1679	1308	1478	1642	1063	1888	1528

Table 5 shows the pounds of milk produced by the individual cows for each week. A study of this table shows that in Lot 1, which received the alfalfa hay during the first period, there was a gradual decrease in milk from the beginning to the close of the test, except in the case of cow No. 26, whose production increased temporarily when the change to bran was made. In Lot 2 there was a marked increase of about 20 pounds of milk per cow in two weeks, when the rations were changed from bran to alfalfa hay. This difference cannot be attributed to a difference in the protein of the ration, as in the previous test, because the protein was practically the same in both rations.

Chart 3 shows graphically the average production of the two lots. Each space from bottom to top represents ten pounds of milk and each space from left to right represents one week. It will be noted that Lot 1, which received the alfalfa hay first, was

CHART 3.—AVERAGE POUNDS OF MILK PRODUCED PER COW PER WEEK



producing, at the beginning, about 8 pounds of milk per cow per week more than Lot 2. This difference continued until the fourth week, when the line representing Lot 1 drops below that representing Lot 2. This was due to cow No. 24 being off feed, as previously stated. Had this not occurred, the line representing Lot 1 would have continued above the line for Lot 2. At the close of the first period, when the alfalfa hay and bran were changed, the line representing the production of Lot 2 immediately rises above that for Lot 1, and continues above until toward the close of the test. The fact that these lines follow each other closely across the chart indicates that there was little difference in the effect of bran and alfalfa hay.

A study of Table 6 shows that the production of fat has not exactly followed the production of milk. In changing from alfalfa hay to bran (Lot 1), there was in every case an increase in the amount of fat, tho the amount of milk decreased. In changing from bran to alfalfa hay (Lot 2), there was a slight increase in the amount of fat, but not in proportion to the increase in milk. This is shown graphically in Charts 3 and 4.

TABLE 6.—PRODUCTION OF FAT PER COW PER WEEK, AND AVERAGE

	Lot 1				Lot 2			
	Alfalfa				Bran			
Week Ending	Cows			Average	Cows			Average
	No. 24	No. 37	No. 26		No. 12	No. 54	No. 13	
Dec. 9	9.08	10.23	7.81	9.04	8.92	6.60	7.33	7.61
" 16	8.60	10.00	7.83	8.81	8.52	6.24	6.67	7.14
" 23	8.71	9.66	7.38	8.58	8.45	6.62	6.69	7.25
" 30	4.11	9.51	7.45	7.02	8.07	6.86	6.37	7.10
Jan. 6	5.62	8.93	7.92	7.49	8.35	6.07	6.36	6.93
" 13	7.30	9.38	7.60	8.09	8.32	6.18	6.74	7.08
" 20	7.01	9.12	7.14	7.76	8.13	5.83	6.38	6.78
" 27	6.82	8.23	6.68	7.24	8.03	5.56	5.60	6.40
Feb. 3	6.61	7.95	6.40	6.99	7.34	5.41	5.63	6.13
" 7	3.98	4.56	4.01	4.18	4.13	3.28	3.10	3.50
Total	67.84	87.57	70.22	75.20	78.26	58.65	60.87	65.92
	Bran				Alfalfa			
Feb. 10	3.02	3.50	2.91	3.14	3.18	2 51	2.58	2.76
" 17	7.30	8.44	6.68	7.47	7.42	5.41	6.80	6.54
" 24	6.69	7.74	6.71	7.05	7.58	5.28	6.09	6.32
Mar. 2	6.82	7.98	6.35	7.05	7.00	5.15	5.76	5.97
" 9	6.73	7.16	6.75	6.88	7.04	4.98	6.00	6.00
" 16	7.17	7.53	6.77	7.16	7.04	5.25	5.63	5.97
" 23	6.55	7.45	6.58	6.86	6.65	4.99	5.46	5.70
" 30	6.87	7.02	6.30	6.73	6.24	5.04	5.28	5.52
April 6	6.85	7.58	7.03	7.15	6.38	5.17	5.62	5.7
" 13	7.07	7.43	6.90	7.13	6.02	5.34	5.01	5.4
" 14	.93	1.13	1.01	1.02	.94	.76	.72	8.
Total	66.00	72.96	63.99	67.64	65.49	49.88	54.95	56.77

CHART 4.—AVERAGE POUNDS OF FAT PRODUCED PER COW PER WEEK

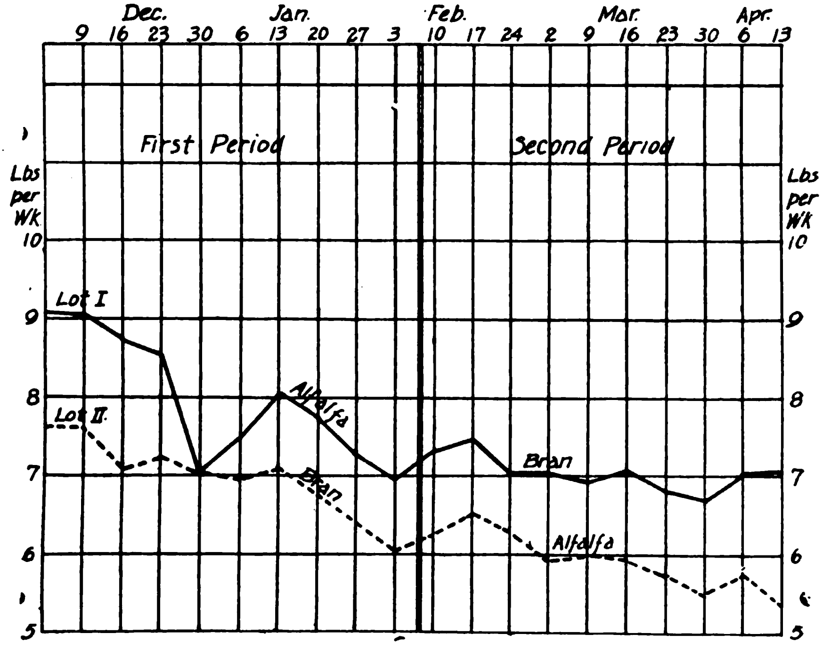


TABLE 7.—TOTAL POUNDS OF MILK AND FAT PRODUCED AND FOOD CONSUMED FOR EACH PERIOD; TOTALS FOR THE ALFALFA HAY PERIODS AND THE BRAN PERIODS

Lot 1	Milk	Fat	Corn meal	Silage	Clover Hay	Bran	Alfalfa hay
First period, alfalfa	5161.8	225.63	1186	5916	1112.2		1546
Second period, bran	4445.8	202.93	1206	6030	1170.0	1608	
Lot 2							
First period, bran	5068.7	197.80	1206	6030	1136.0	1561	
Second period, alfalfa	4591.9	170.32	1206	6030	1161.5		1608
Totals							
Alfalfa periods	9753.7	395.95	2392	11946	2273.7		3154
Bran periods	9514.5	400.73	2412	12060	2306.0	3169	
Difference in favor of alfalfa hay	239.2	-4.78	-20	-114	-32.3	-15	

Table 7 shows that while fed alfalfa hay the cows produced 239.2 pounds more milk and 4.78 pounds less butter fat than while fed bran. They also consumed 20 pounds less corn meal, 114 pounds less silage, 32 pounds less clover hay, and 15 pounds less alfalfa hay than bran, because one cow was off feed. This difference in the amount of feed is small and amounts to little more than one day's ration for the lot, and could not account for more than 75 pounds of milk. On the same feed basis, therefore, the cows produced 314 pounds more milk and 3.5 pounds less butter fat while on the ration containing the alfalfa hay. This shows alfalfa equal to or a little better than bran for milk production under conditions which are the same as those existing on most dairy farms.

This result does not quite agree with the findings of the Pennsylvania, Tennessee, and some other stations, which found alfalfa meal and alfalfa hay slightly inferior to bran. It is safe to say that when alfalfa can be grown on the farm, it is the best substitute for bran in feeding dairy cattle.

It should be noted that in this demonstration only choice alfalfa hay was fed. The cows receiving the alfalfa hay were in better physical condition at the end of each period than were those receiving bran.

These two demonstrations indicate that alfalfa hay will not only supply a palatable roughage and a large amount of protein, but also that alfalfa keeps the animals in better physical condition than such rations as timothy hay with grains high in protein. Like the other legumes, it takes large amounts of nitrogen from the air and causes it to be fixed in the soil. For these reasons we urge that every dairyman make a strenuous effort to grow at least a small piece of alfalfa. For methods of growing, see Illinois Agricultural Experiment Station Bulletin No. 76.

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UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN NO. 147

MARKET CLASSES AND GRADES OF MEAT

BY LOUIS D. HALL

URBANA, ILLINOIS, JULY, 1910

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 147

MARKET CLASSES AND GRADES OF MEAT

By LOUIS D. HALL

URBANA, ILLINOIS, JULY, 1910

The Station.

SUMMARY OF BULLETIN No. 147

1. Objects: To describe and illustrate the standard classes and grades of beef, veal, mutton and pork recognized in Chicago wholesale markets; and to define technical terms that are commonly used in wholesale meat quotations.

BEEF

2. The general divisions of the beef trade are (1) Carcass Beef, (2) Beef Cuts, and (3) Cured Beef Products. Page 165.

3. CARCASS BEEF.—The classes are *Steers, Heifers, Cows* and *Bulls and Stags*. They differ not only in sex, but also in the uses to which they are adapted. Page 155.

The grades within these classes are *prime, choice, good, medium, common* and *canners*. The grades are based on differences in form, thickness, finish, quality, soundness and weight. Page 156.

The terms "Native," "Western" and "Texas" beef each include various classes and grades of carcasses, and refer to general differences in form, finish and quality. Page 185.

The terms "Yearlings," "Distillers," "Butcher" and "Kosher" also include various classes and grades of beef, and merely indicate characteristic features of carcass beef use by certain branches of the trade. Page 186.

"Shipping beef" refers to that sent to eastern cities and consists principally of steers, heifers and cows of medium to prime grades. Export beef consists largely of medium to prime steers. Page 189.

4. BEEF CUTS.—The "straight cuts" of beef are *Loins, Ribs, Rounds, Chucks, Plates, Flanks* and *Shanks*.. (Fig. 22.) Page 190.

The grades of beef cuts are *No. 1, No. 2, No. 3* and *Strippers*. The grade of a beef cut depends upon its thickness, covering, quality and weight. Page 190.

5. CURED BEEF PRODUCTS.—These are classified as (1) Barreled, (2) Smoked and (3) Canned Beef. Page 208.

Barreled Beef is graded as *Extra India Mess, Extra Plate, Regular Plate, Packet, Common Plate, Rolled Boneless, Prime Mess, Extra Mess, Rump Butt* and *Mess Chuck Beef, Beef Hams* and *Scotch Buttocks*. Page 209.

Smoked Beef consists of *Dried Beef Hams, Dried Beef Clods* and *Smoked Brisket Beef*. Page 210.

Canned Beef consists principally of *Chipped Beef, Beef Loaf, Corned* and *Roast Beef*. Page 210.

VEAL

6. The divisions of the veal trade are (1) Carcass Veal and (2) Veal Cuts. Page 211.

7. CARCASS VEAL.—The grades are *choice, good, medium, light* and *heavy*. The grade of a veal carcass depends upon its form, quality, finish and weight. Page 211.

The terms "Native" and "Western" veal each include several grades of calves, and refer to general differences in form, quality, and finish. Page 216.

8. VEAL CUTS.—The regular veal cuts are *Saddles* and *Racks.* They are graded as *choice, good, medium* and *common,* according to the same factors as carcass veal. Fig. 36.) Page 217.

Subdivisions of the regular cuts are made in some markets and similarly graded. (Fig. 36.) Page 217.

MUTTON AND LAMB

9. The divisions of the trade are (1) Carcass Mutton and Lamb and (2) Mutton and Lamb Cuts. Page 222.

10. CARCASS MUTTON AND LAMB.—The classes are *Wethers, Ewes, Bucks, Yearlings* and *Lambs.* Page 223

The grades within these classes are *choice, good, medium, common* and *culls.* The grades are based on differences in form, quality, covering and weight. Page 223.

The shipping trade goes principally to cities in the eastern seaboard states and consists largely of medium to choice lambs. Page 242.

11. MUTTON AND LAMB CUTS.—The leading cuts are *Saddles* and *Racks,* together with *Legs, Loins, Short Racks, Stews* and *Backs.* (Fig. 51.) They are graded in the same manner as carcass mutton and lamb. Page 245.

PORK

12. Hog products are described under three heads: (1) Dressed Hogs, (2) Pork Cuts and (3) Lard. Page 252.

13. DRESSED HOGS.—The classes are *Smooth, Heavy, Butcher, Packing* and *Bacon Hogs, Shippers* and *Pigs.* The classification is based on the uses to which the hogs are adapted. Page 252.

Distinct grades are recognized only in the *Packing* and *Bacon* classes, the former being based on weight and the latter chiefly on quality and finish. Page 253.

14. PORK CUTS.—The classes are *Hams, Sides, Bellies, Backs, Loins, Shoulders, Butts and Plates,* and *Miscellaneous.* (Fig. 61.) Page 263.

Pork cuts are quoted as fresh pork, dry-salt and bacon meats, barreled or plain-pickled pork, sweet-pickled meats, smoked meats, "English" meats and boiled meats, respectively. Page 263.

The grading of pork cuts is much more complex than that of other meats. It involves not only their quality, shape, finish and weight, but also the styles of cutting and methods of packing used. Page 267.

15. LARD.—The grades are *Kettle-Rendered Leaf, Kettle-Rendered, Neutral, Prime Steam, Refined* and *Compound Lard.* The grading is based on the kinds of fats included, method of rendering, color, flavor and grain. Page 288.

BEEF

	Classes	Grades	Page	Figure
CARCASS BEEF	Steers	Prime	160	1
		Choice	162	2, 4
		Good	163	3, 4
		Medium	165	5
		Common	166	6
	Heifers	Prime	168	7
		Choice	170	8
		Good	171	9
		Medium	172	10
		Common	173	11
	Cows	Choice	175	12
		Good	176	13
		Medium	177	14
		Common	178	15
		Canners	179	16
	Bulls and Stags	Choice	180	17
		Good	182	18
		Medium	183	19
		Common	184	20
	Miscellaneous			
	"Native," "Western" and "Texas" Beef		185	
	"Yearlings," "Distillers," "Butcher" and "Kosher" Beef		186	21
	Shipping and Export Beef		189	
BEEF CUTS	Loins	No. 1, No. 2, No. 3, Strippers	195	23, 24
	Ribs	" " " "	198	25
	Rounds	" " " "	200	26
	Chucks	" " " "	203	28, 29
	Plates	" " " "	206	31
	Flanks	" " "	206	32
	Shanks	" " "	207	33
	Suet		208	
CURED BEEF PRODUCTS	Barreled		208	
	Smoked		210	
	Canned		210	

VEAL

	Classes	Grades	Page	Figure
CARCASS VEAL		Choice	214	34
		Good	214	34
		Medium	215	35
		Light	215	35
		Heavy	215	35
	"Native" and "Western" Veal			
VEAL CUTS	Saddles	Choice	218	37a
		Good	218	37a
		Medium	219	37b
		Common	219	37b
	Racks	Choice	220	38a
		Good	220	38a
		Medium	221	38b
		Common	221	38b

MUTTON AND LAMB

	Classes	Grades	Page	Figure
CARCASS MUTTON AND LAMB	Wethers	Choice	227	40
		Good	27	40
		Medium	227	40
		Common	227	40
	Ewes	Choice	228	41
		Good	228	41
		Medium	229	42
		Common	229	42
		Canners	229	42
	Bucks	Good	232	43
		Medium	232	43
		Common	232	
	Yearlings	Choice	233	44
		Good	233	
		Medium	233	44
	Lambs	Choice	235	45,46a
		Good	235	45,46a
		Medium	235	45,46b
		Common	235	45,46b
		Culls	237	
MUTTON CUTS	Saddles Legs Loins	Choice	248	52
		Good	248	52
		Medium	248	52
		Common	248	52
	Racks Short Racks Stews	Choice	248	52
		Good	248	52
		Medium	248	52
		Common	248	52
	Backs		249	
LAMB CUTS	Saddles Legs Loins	Choice	250	53
		Good	250	53
		Medium	250	53
		Common	250	53
	Racks Short Racks Stews	Choice	250	53
		Good	250	53
		Medium	250	53
		Common	250	53
	Backs		252	

PORK

	Classes	Grades	Page	Figure
DRESSED HOGS	Smooth Heavy Hogs		254	54
	Butcher Hogs		255	55
	Packing Hogs	Heavy	256	56, 57
		Medium	256	56
		Light	258	
	Bacon Hogs	Choice	259	58
		Good	260	59
		Common	260	59
	Shippers		262	60
	Pigs		262	60
PORK CUTS	Hams	Regular Short-Cut	269	62, 64
		Skinned	269	62
		Boneless Rolled	270	65
		Regular Long-Cut	269	63
		Stafford	269	63
		Manchester	269	63
		Italian	269	63
	Sides	Short Ribs		
		Regular	271	
		Jobbing	273	66
		Hard	272	
		Extra	273	66
		Square	272	
		Short Clears		
		Regular	273	66
		Square	274	
		Extra	273	66
		English Bacon Sides		
		Wiltshire	275	67
		Cumberland	275	67
		Dublin	275	67
		Long Rib	274	
		Long Clear	275	67
		Yorkshire	275	67
		Staffordshire	275	67
	Bellies	Dry-Salt	277	68
		Sweet-Pickle	277	68
		Breakfast-Bacon	277	68, 70
		English	277	68

PORK—CONTINUED

	Classes	Grades	Page	Figure
PORK CUTS CONTINUED	BACKS	SHORT RIB	227	69
		SHORT CLEAR	277	69
		SHORT FAT	277	69
		LONG FAT	279	61
	LOINS	REGULAR	273	66b
		LOIN ROLLS	280	
	SHOULDERS	ROUGH	282	72
		REGULAR	280	
		PICNIC	284	74
		NEW YORK CUT	282	72
		SKINNED	282	72
		SQUARE	282	72
		NEW ORLEANS CUT	282	72
		BONELESS ROLLED	283	
	BUTTS AND PLATES	BOSTON STYLE BUTTS	282	73
		MILWAUKEE STYLE BUTTS	283	
		BONELESS BUTTS	282	73
		BUFFALO STYLE BUTTS	283	
		NEW YORK STYLE BUTTS	282	73
		PICNIC BUTTS	282	73
		DRY-SALT BUTTS	284	75
		SQUARE-CUT BUTTS	284	75
		REGULAR PLATES	282	73
		CLEAR PLATES	282	73
		BACK PLATES	285	
	MISCELLANEOUS	MESS PORK	273	66a
		BELLY PORK	286	
		BACK PORK	286	
		SHOULDER PORK	287	
		SPARERIBS	284	75
		TRIMMINGS	288	
LARD	KETTLE RENDERED LEAF		288	
	KETTLE RENDERED		288	
	NEUTRAL	No. 1	289	
		No. 2	289	
	PRIME STEAM	CHOICE	289	
		REGULAR	289	
	REFINED		290	
	COMPOUND		290	

MARKET CLASSES AND GRADES OF MEAT

BY LOUIS D. HALL, ASSISTANT CHIEF IN ANIMAL HUSBANDRY

The objects of this bulletin are to describe and illustrate the standard classes and grades of beef, veal, mutton and pork of the Chicago wholesale trade, and to define various technical terms that are commonly used in wholesale meat quotations.

The most intelligent production of animals for slaughter involves a knowledge of the standard requirements of the meat market. Breeders, feeders or investigators who consider only the cost of production and the market value of the live animal, ignoring the demands of the meat trade, overlook one of the most important factors that affect the live stock market and may thus fail to follow the most rational lines of improvement in breeding and feeding.

Live stock producers, however, have exceedingly limited opportunities for becoming familiar with this subject. The rapid development of transportation, refrigeration, slaughtering and packing facilities has led to the present system of large markets separated by distances which make them practically inaccessible to a large majority of stockmen. Further, since animals are sold by live weight the shipper feels concerned with their value on foot rather than their dressed yield. Finally, definite classifications are lacking in some branches of the meat trade, and the classifications in use are often complicated by variations in market conditions. The trade has become so vast and complex that it is very difficult—and has become increasingly difficult with each succeeding year—for one not engaged in the meat business to secure a definite knowledge of its various branches. The present tendency toward a more highly centralized organization of the retail meat trade in some localities increases still further its inaccessibility to the live stock producer. As a result of these conditions meat dealers and consumers are far more familiar with the subject than meat producers. The following descriptions, therefore, are intended primarily to be of value to breeders and feeders who do not have opportunities to secure the information directly. With an understanding of meat trade requirements it is possible for a stockman to judge the carcass yield and quality of his animals as intelligently as buyers at the stock yards; because his knowledge of the feeds used, length of feeding period and gains made, are as essential in making such estimates as the apparent form, condition and quality of the fat animal, upon which points the buyer must chiefly rely.

The descriptions herein presented are based on data secured by the writer in a personal investigation at wholesale meat markets at the Union Stock Yards, Chicago, which are the largest establishments of their kind in the world; also at prominent wholesale and retail markets in Chicago and other cities which are supplied from the large houses at the Union Stock Yards. The engravings are from photographs taken under the writer's direction at the markets and at this Experiment Station. The officials and salesmen of the large packing houses and the retail dealers, jobbers, and other expert authorities who were consulted gave the most willing assistance. The valuable suggestions and information furnished by these gentlemen are gratefully acknowledged.

The classifications under which meats are quoted differ slightly in different American cities according to the nature of the supplies received and the peculiarities of the local trade. They are essentially alike, however, at all the great packing centers of this country, and since most American wholesale markets are supplied from these centers, the classification as presented may be regarded as standard.

Market classifications of meat, like those of live stock, are more or less flexible because of the varied and varying conditions which affect the industry. In those branches of the trade in which the current market terms are vague and the classifications loose, the writer has attempted to present the subject as systematically as possible without exaggerating the classification actually in use. It is impracticable to include here all the minor and intermediate grades of meat within each class, and this bulletin describes only those classes and grades which may be considered standard or representative. It is also difficult to describe a grade of meat independently of others within its class. Generally, therefore, each grade should be studied in connection with those above and below it.

Attention is called to the fact that the following classifications are those of the wholesale meat trade and not of the live stock market, and that they are described independently of the latter. The weights given refer to dressed carcasses and cuts, and in no case to live animals. Altho in some instances the classes of meat correspond to those of live stock, they are in the main quoted and sold quite separately and differently from the live animals from which they are obtained. It is outside the objects of this bulletin to consider the relation of the animal to its meat products. It is hoped, however, that it will assist materially in placing such investigations on a more exact and uniform basis than would otherwise be possible, and that it will increase the number and significance of future investigations along this line.

BEEF

The general divisions of the beef trade are (1) *Carcass Beef,* (2) *Beef Cuts* and (3) *Cured Beef Products.* The term *Fresh Beef* includes carcass beef and beef cuts. It refers both to chilled beef, which is held in refrigeration at 36° to 38° F. for a few days or weeks only, and to frozen beef, which is stored at 10° to 15° F., usually for several months. About four-fifths of the beef trade consists of fresh beef, the remainder being converted into various products such as barreled, smoked and canned beef, sausage meats, etc.

CARCASS BEEF

About one-half the supply of fresh beef sold in wholesale markets is carcass beef (sides and quarters). The two sides or halves of a carcass are termed a "cattle". In the right or "closed" side the inner surface of the kidney fat is attached to the loin while in the left or "open" side it is free and a portion of the "skirt" (diaphragm) extends to the tenth* rib, forming the "hanging tenderloin". The two sides are nearly equal in weight, but the open one is often one percent the heavier. When sides are sold separately no discrimination in price is made between rights and lefts.

Sides are quartered or "ribbed" between the twelfth and thirteenth ribs* when taken from the chillroom either for shipment or local delivery, except export and "Boston" cattle, which are cut between the tenth and eleventh ribs. The quarters are called "fores" and "hinds". In shipping and export trade, the four corresponding quarters are regarded as a carcass of beef; that is, they are sold as "straight cattle" rather than miscellaneous sides or quarters. In "car-route" and local city trade carcass beef is to a considerable extent handled as separate "fores" and "hinds".

Regular hindquarters contain 47 to 49 percent of the carcass weight and fores 51 to 53 percent, the average being about 48 percent hinds and 52 percent fores. In "exports" the quarters are practically equal in weight. Hinds are quoted about 25 percent higher than fores in the cold months and up to 40 percent higher in summer. The influence of season upon the price is due to the large amount of boiling and stewing pieces in the forequarters, which meats are both more palatable and more economical to cook during the winter season than in warm weather and consequently are in greater demand at that time.

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*Beef carcasses contain thirteen pairs of ribs. It is customary to number them from the neck backward.

Carcass beef which is thick and fat enough so that the entire side can be sold over the butcher's block in retail cuts is known as "block beef" or "side beef". "Cutters" are dressed cattle that are not sufficiently thick-fleshed nor fat to be entirely utilized by the retailer, but contain certain wholesale cuts (loins and ribs) which may be so used. "Canners" are those carcasses from which none of the regular wholesale cuts suitable for butcher-shop use can be obtained, and which, consequently, must be divided into smaller cuts such as boneless fresh meats and cured beef products.

CLASSES AND GRADES OF CARCASS BEEF

The classes of carcass beef are *Steers, Heifers, Cows,* and *Bulls and Stags.* This classification is based not merely upon differences in sex, but also upon the general uses to which they are adapted, as described in connection with each class.

Within the four classes, side beef is graded as *prime, choice, good, medium, common* and *canners.* In the markets the highest grade is sometimes termed "extra choice" or "fancy" beef; the term "fair" is frequently used instead of *medium,* and *canner* sides are often called "culls".

Grading Carcass Beef

The grade to which a carcass, side or quarter, belongs depends upon its *form, thickness, finish, quality, soundness* and *weight.*

By *form* is meant the shape or "build" of the side, its general outlines and the proportions of its different parts. Ideal conformation consists of compactness, i.e., good width in proportion to length; short shanks and neck; and full rounds, loin and ribs. It is associated more or less closely with a proper degree of thickness and is also partially dependent upon the covering or finish of the carcass. Large plates,* "hollow" loins, prominent hips, thin chucks or "rangy" loosely coupled sides are especially discriminated against. A "rimmy" side is one showing an unusual degree of curvature in the ribs, giving the side a warped appearance and corresponding to paunchiness in live cattle.

Thickness of a carcass refers to the amount of lean flesh it carries. Thick-meated loin and ribs and full, compact rounds and chucks are especially essential. "Built like a cart-horse" describes the fleshing demanded in high-grade carcasses. In the case of quartered sides the depth of lean meat on the ribs is readily seen. It is true that thickness depends somewhat upon the finish of the carcass; but there is a clear distinction between thickness due to fatness and thickness due to muscular flesh. Also, quality and firmness of flesh must be considered in judging thickness. For example, carcasses of distillery cattle often have a plump, thick appearance which is deceptive in that the flesh is not firm. Only the knife can completely reveal the thickness of a side and the proportions of fat and flesh. The appearance of an uncut side often misleads the most expert dealers with regard to the actual thickness of flesh.

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*For explanation of cuts see Fig. 22, page 191.

Finish corresponds to "condition" in the live animal; in other words, it refers to the amount and distribution of fat on the carcass, and to the quality of flesh so far as it depends upon the degree of fatness. Perfect finish involves a smooth covering of firm, white fat over the entire carcass, with the greatest depth along the back (about one-fourth inch on 500-pound carcasses, up to three-fourths inch on 900-pound cattle); a white brittle "kidney" of medium size; and a lining of fat deposited in flakes or rolls on the inner surface of the ribs. The rounds and shanks are covered last in the process of fattening, hence these parts are indications of the last degree of finish. The fat must not be excessive at any point, especially over the loin and ribs, because this indicates either an overdone condition or a tendency toward thick crusty covering without good marbling, i.e., mixture of fat thru the lean flesh. The highest quality of beef is that which contains the largest proportion of well marbled lean with the minimum of excess fat, but a certain amount of the latter is indispensable in prime beef. In the lowest grade, outside fat is entirely lacking. A carcass carrying soft, "gobby" fat sells at a discount. A "green" or "grassy" appearance of the flesh indicates a marked lack of finish; it is a watery, flabby condition which is characteristic of grass-fed cattle.

Quality in beef is so closely associated with form, thickness and finish that the term is often used loosely to cover all three points. In a more definite sense, however, quality has reference to size, color and softness of the bones, smoothness and grain of flesh, color and general appearance of carcass, and an absence of coarseness in general. A carcass may be thick, fat and of excellent form and yet fall below the highest grade because it lacks quality in one or more of the above particulars.

Quality of flesh in a carcass depends chiefly upon its smoothness, grain and color. Rough, uneven flesh detracts from the appearance and usefulness of the beef. Coarse grained, stringy, fibrous flesh is usually an indication of poor breeding, stagginess, advanced age or improper nourishment of the animal. Lack of grain and firmness, on the other hand, go with beef that lacks the age required for mature beef. Very young beef seldom has "substance" or marbling, and is high in percentage of water. It is considered by beef experts that carcasses of cattle under fifteen to eighteen months old are not generally mature enough for prime beef cuts, and those above three to four years old are usually past the point of highest quality, being too coarse in bone or grain of meat or uneven in finish. There are, of course, individual exceptions outside these limits of age.

Quality of bone is judged principally from the chine, breastbone and ribs. (Fig. 22.) The bones should be as small as consistent with the weight of the carcass. They are also a valuable indication of the age and consequently the quality of flesh of a carcass. The "buttons" or cartilages on the ends of the chine bones (spinous processes) are soft and white in carcasses of cattle up to one and one-half or two years old, and the bones or processes to which they are attached are soft and red with blood vessels. Thereafter the "buttons" or "pearls" gradually ossify, and at three years have changed to a dark gray color but are somewhat distinct from the bone proper until about the fifth year. Similar cartilages on the breast-bone disappear thru ossification before the third or fourth year. The breast-bone, back-bone, ribs and pelvis gradually harden and whiten, especially after the age of eighteen months, and the segments of the rump bone unite, forming an apparently continuous surface. The bones of cows and heifers turn hard and white earlier than those of steers. In splitting the carcasses of old cows, bulls and oxen the chine bones are so flinty as to break and crush rather than cut, which gives the side a ragged appearance.

In color the fat should be a clear white and the flesh a bright, rich red. A "fiery" carcass is one the surface of which is spotted with highly colored blood vessels, due to incomplete bleeding when slaughtered. This indicates a similar condition within the lean and such sides usually "rib" dark. It may be due either to a feverish condition, fatigue from long shipment, pregnancy, or excitement at time of slaughter. A dark yellow fat is characteristic of Jersey and Guernsey cattle; it is also believed to be an individual peculiarity of some cattle, and to be due to the feed in some cases. It is not always an indication of poor quality but is generally associated with dark colored and poorly marbled meat. "Spotters" are carcasses in which brown or black spots are found in the flesh, varying in size from mere specks to one-eighth inch in diameter. These spots are sometimes found on the flank and skirt (diaphragm) but usually are not visible until the side is cut open in quartering. They are usually found in choice native beef and their cause is not known. Carcasses are generally sold subject to the return or discount of those which cut out spotted or very dark. Such defects detract about 25 percent from the value of a carcass.

Soundness is considered in grading all beef carcasses, but most of all in the higher grades. A large percentage of carcasses are sold at a discount or sent to the cutting room on account of bruises, which injure both the appearance and keeping quality of the meat, altho as a rule the injured portion is trimmed off in the dressing process. Bruises are found most commonly on the hips, shoulders, and plates, these being the most exposed parts of the carcass. Such bruises are usually inflicted in shipment of cattle to market or in handling them in the stock yards. Unnecessary blows over the backs and loins of cattle cause the discounting of many carcasses which would otherwise grade high. Cattle which have been shipped long distances, such as Texas and Western range cattle, are bruised to a considerable extent, and droves of horned cattle show more carcass bruises than others, as a rule. Large brands are often visible on the carcass, sometimes sufficiently to diminish its value. "Bone-sour", which is caused by decomposition of the "joint water" of the hip-bone, is a common defect in heavy carcass beef. Especial care must be taken in the case of export beef both as to "bone-sour" and bruises, either of which, however slight, excludes a side from export trade. Over-ripe beef, which has been held in storage too long or with insufficient refrigeration or ventilation is also considered unsound. If well covered with fat it may be allowed to mold on the outside, otherwise a moldy condition indicates that the meat is tainted.

Weight is of importance in grading beef in the sense that the heavier carcasses are generally better in form, thickness, finish and quality than the lighter ones, and because different classes of retail trade differ as to the size of the steaks, roasts and other cuts which they demand. Consequently a system of grading by weight is of convenience to both buyer and seller. In shipping and export trade, carcass beef is assorted according to the following weights: (1) over 950 lb.; (2) 850-950 lb.; (3) 750-850 lb.; (4) 650-750 lb.; (5) 600-650 lb.; (6) 550-600 lb.; (7) 500-550 lb.; (8) under 500 lb. The heaviest carcasses seldom exceed 1050 pounds; the minimum weight is about 250 pounds, but comparatively few beef carcasses are sold in averages below 400 pounds.

Heifers and cows are separated into only four or five grades ranging from 450 pounds or under, to 750 pounds or over. Bulls and stags are not handled as carcass beef sufficiently to necessitate grading by weight, and the bulk of those sold in the carcass weigh 700 to 950 pounds. The influence of weight in determining the market grade of a carcass varies with different branches of the

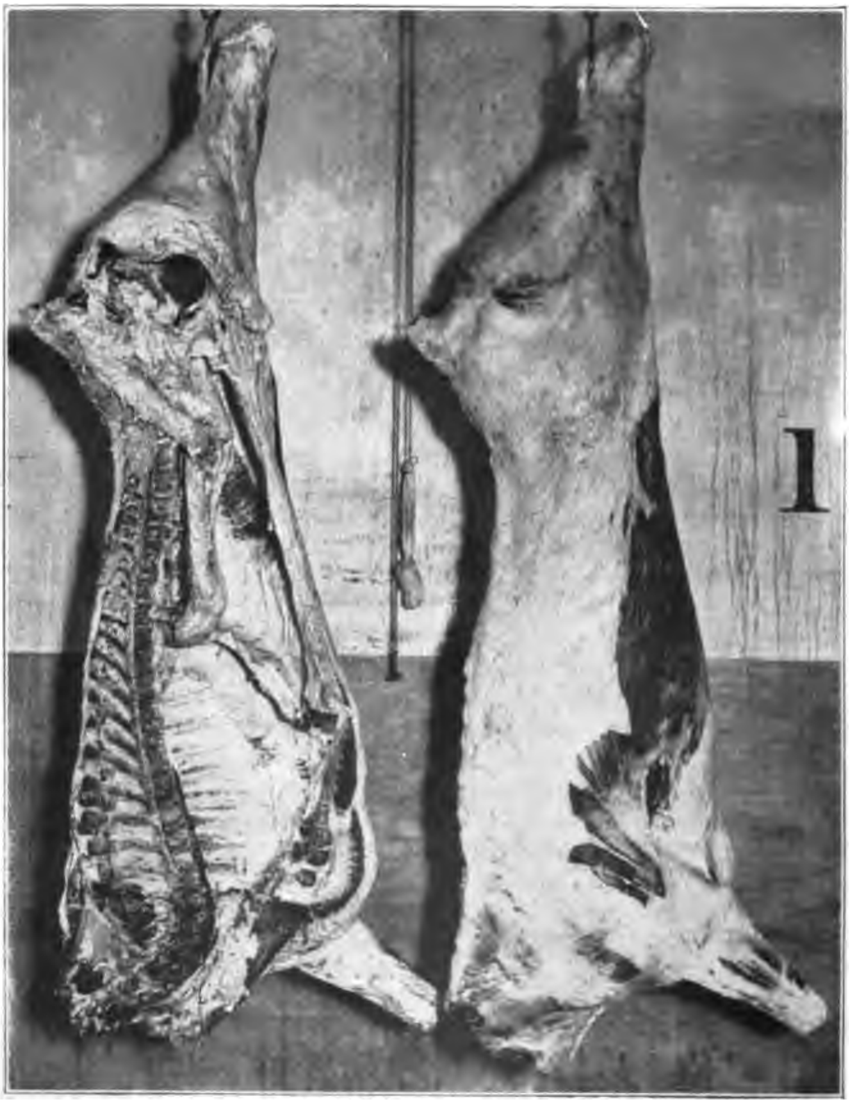

FIG. 1. PRIME STEER.

trade and with the season, as will be noted in describing the various classes of beef.

As to the relative importance of the above factors in grading carcass beef, it may be said that in the higher grades finish is particularly essential, with thickness, quality and form of about equal importance. In the medium and lower grades, finish is a minor item and quality is of less relative importance than thickness and form. Weight and soundness are more important in the higher than in the lower grades.

STEERS

Steer carcasses are identified by the cod fat, and generally by their full, fleshy rounds and loins, heavier, coarser bones, and short necks as compared with cows. They show more quality and finish than any other class, and are sold as carcass beef more extensively than any other class except heifers. The grades are *Prime, Choice, Good, Medium* and *Common.*

Prime steers ("fancy" or "extra choice") completely fill all the requirements of carcass beef described on pages 156 to 159. They are the "show cattle" of the beef trade. They weigh 900 to 1100 pounds (dressed) altho it is not uncommon to find sufficient finish and quality in carcasses below 800 pounds to grade prime. Finish is of special importance because this grade of beef supplies a trade which requires rich, tender steaks and roasts even at the expense of considerable waste tallow. The demand for a limited amount of prime beef is comparatively constant and uniform. It supplies the highest class of city, shipping and export trade. Excepting a few weeks at the holiday season, however, little distinction is made between fancy and choice beef. See Fig. 1.

Choice steers are excellent in shape and thickness but lack the high finish demanded by the most select holiday trade. They are the highest grade of dressed beef found regularly in the market, and are uniformly compact, thick and smooth. Any indications of coarseness or a marked lack of finish bar a bullock from this grade. They are most in demand from October until Lent. The bulk weigh 800 to 950 pounds. Choice cattle that are shipped or exported are handled in the quarter, while those used locally are sold chiefly as No. 1 wholesale cuts except the plates and flanks, which are largely sold as barreled beef. See Figs. 2, 4.

Good steers are somewhat deficient in either finish, thickness or form, but at the same time have sufficient covering to show that they have been fattened on a grain ration. Or, they may be thick and well finished but coarse in bone and flesh, or show too much age. They commonly weigh 650 to 850 pounds. Steer carcasses weighing 750 to 800 pounds generally sell lower than heavier cattle of the same quality and finish because they are too light for the jobbing or hotel trade and too heavy for the retailer. This grade of beef is used largely in the shipping trade, and is also sold to hotels and restaurants that cater to commercial rather than fashionable patrons. See Figs. 3, 4.

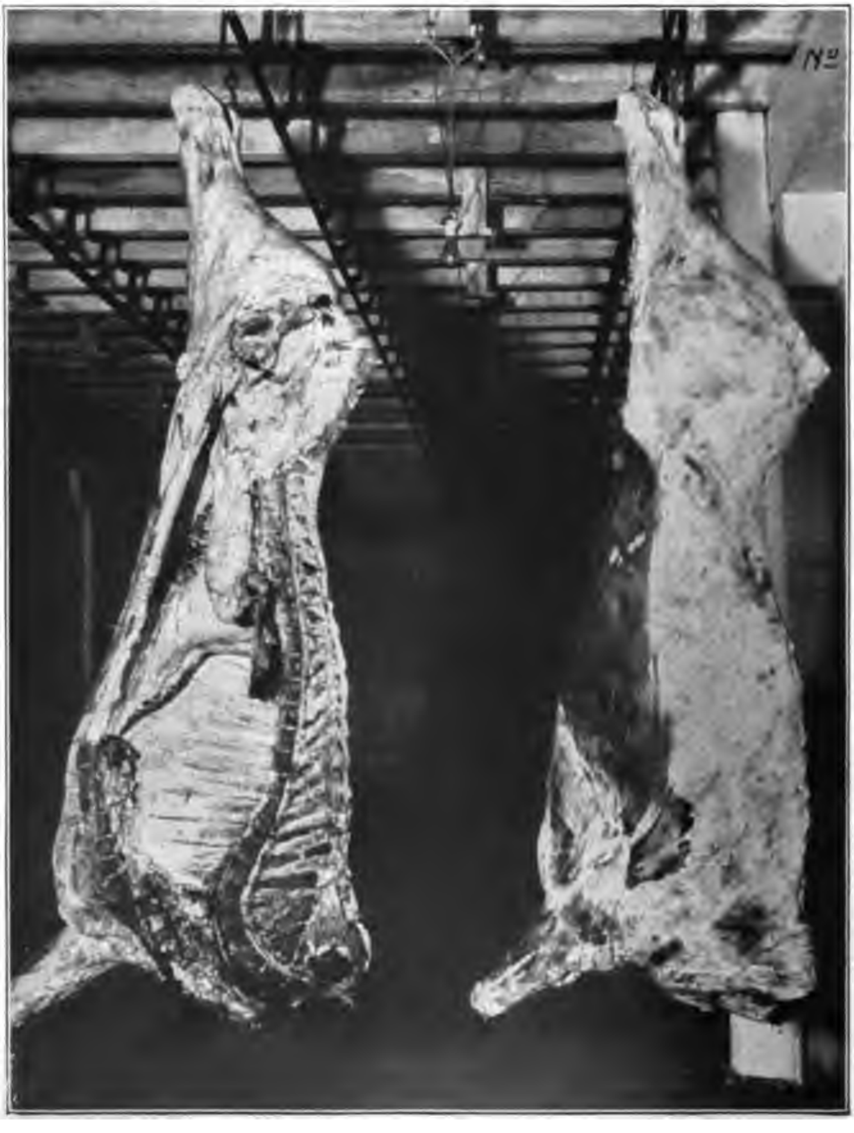

FIG. 2. CHOICE STEER.

Medium steers are so graded because of a deficiency in any or all of the points mentioned in reference to the higher grades, but to a more marked extent. As a rule they are about as fat as good steers but many have no covering over round or chuck, and a common feature of the grade is coarseness of quality and conformation. Some slightly staggy cattle are included. Heavy plates, hollow loins, prominent hips and shoulders, light rounds, long necks, dark color, "grassy" flesh or other equally objectionable points are found in this grade. They are the lowest grade of bullocks that are ordinarily sold in the carcass, and the majority of the supply is sold to retail markets. The wholesale cuts of medium

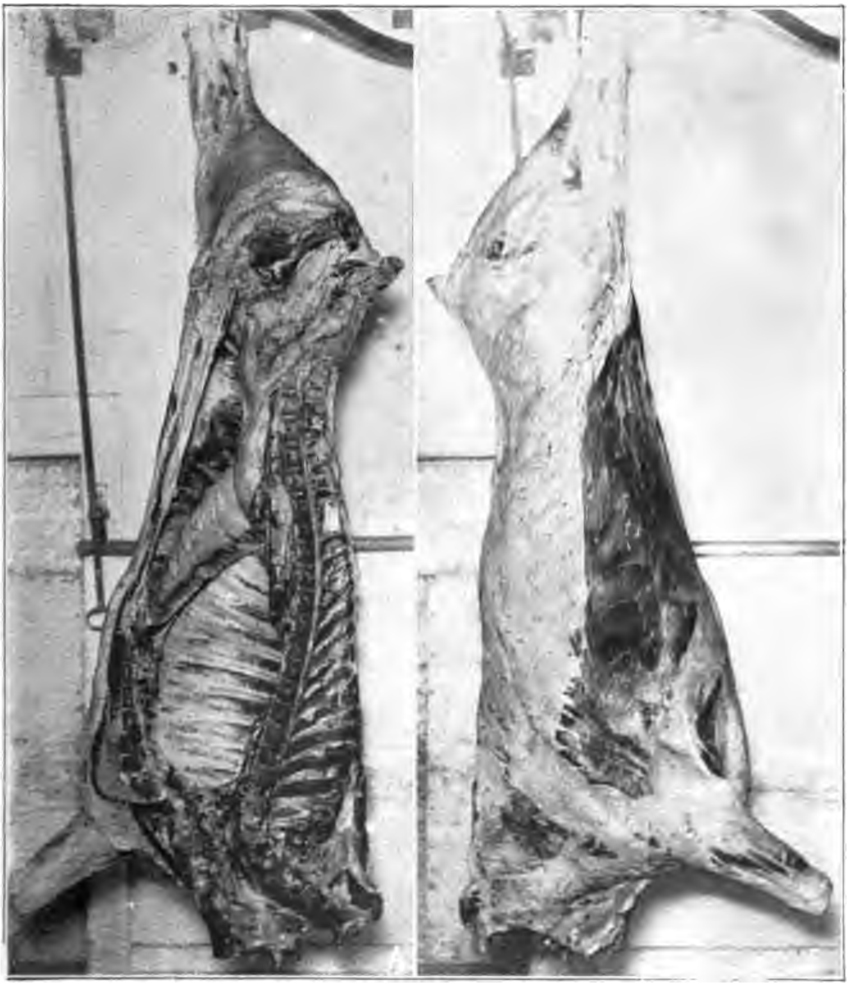

FIG. 3. GOOD STEER.

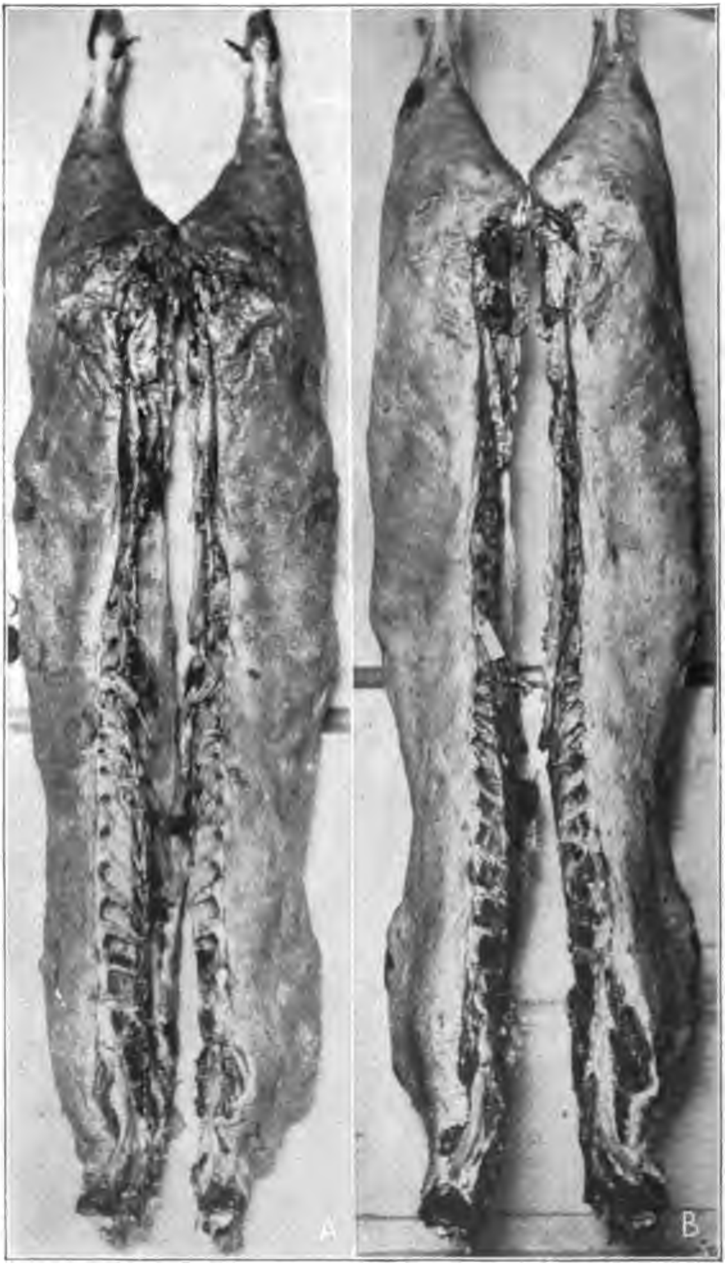

FIG. 4. A, CHOICE STEER. B, GOOD STEER.

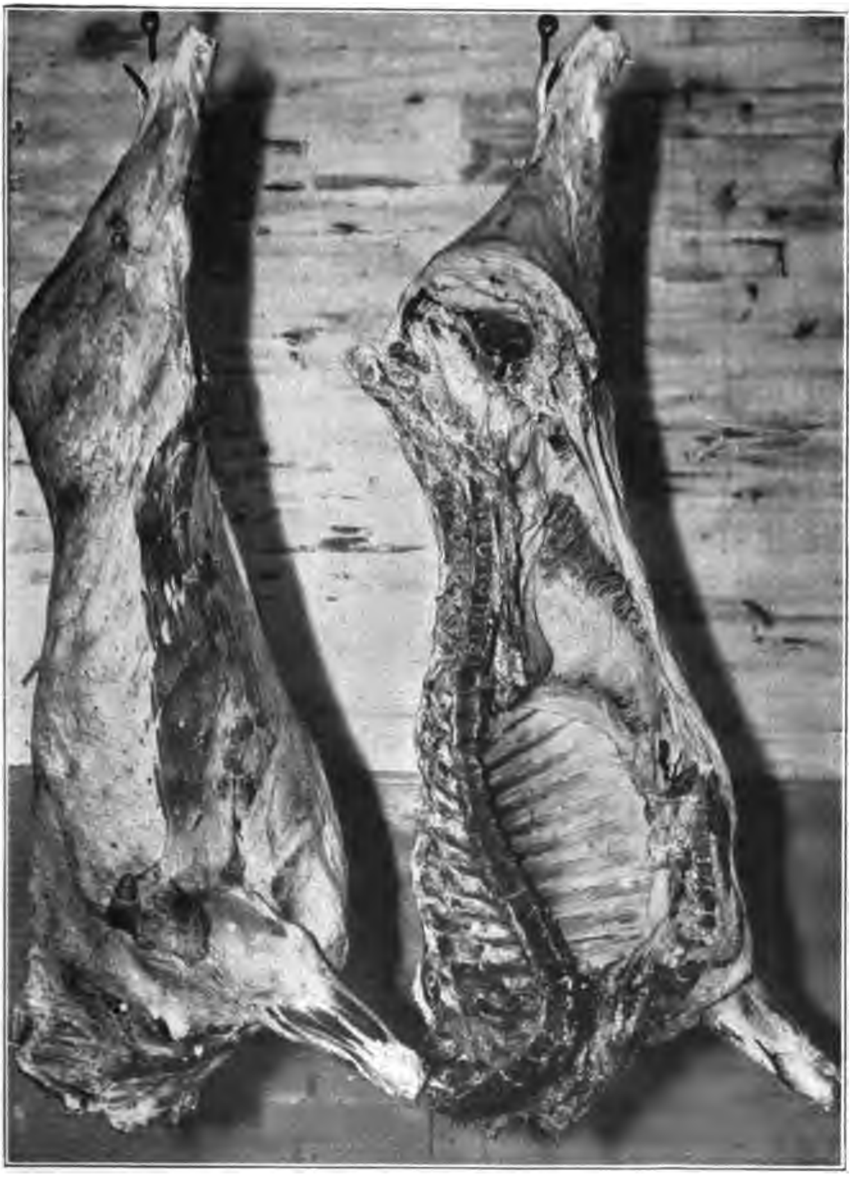

FIG. 5. MEDIUM STEER.

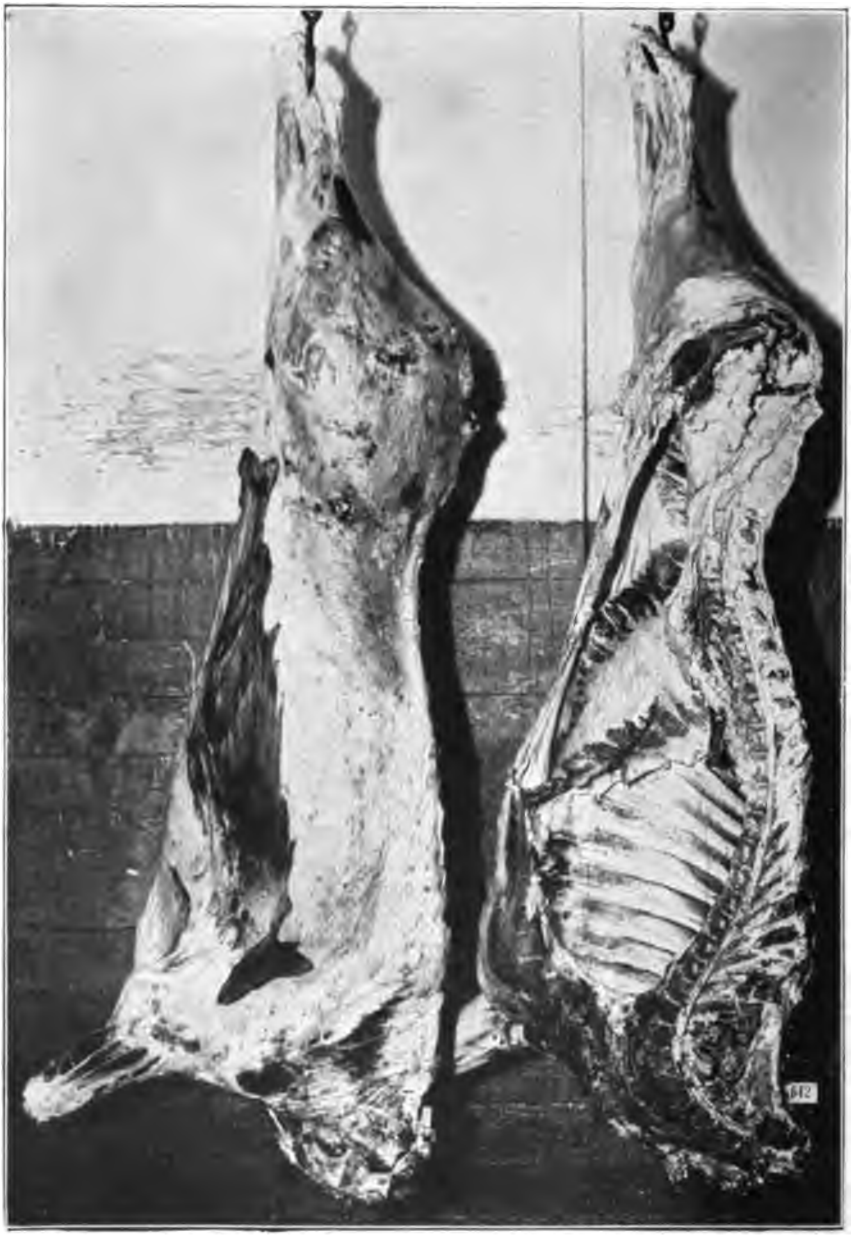

FIG. 6. COMMON STEER.

Western steers are frozen in large quantities during the fall season. The general run weigh 550 to 750 pounds and some plain carcasses are included up to 900 pounds. See Fig. 5.

Common steers have but little outside fat and kidney suet. They are angular, long in shank and neck, and generally dark colored or "grassy" in flesh. Many sides which are disqualified from higher grades by reason of bruises, stagginess, "off color" (fiery, spotted or yellow), or other defects, are sold as common. (Fig. 6.) They average 450 to 600 pounds. When sold as carcass beef they are taken by jobbers or retailers who supply a cheap trade. Ordinarily, however, they enter the trade as wholesale cuts and barreled beef. They are the lowest grade of steer sides with the exception of an inconsiderable number of culls used for canning purposes. The latter are comparable in quality with common and canner cows. The proportion of common carcasses is much smaller in the steer class than in others because thin steers are extensively shipped from the market to the country as feeders, whereas nearly all cattle of other classes sold at the large markets are slaughtered.

HEIFERS

Heifer carcasses are distinguished from steers by the bag (udder), and as a rule they have smaller bones, slightly more angular rumps, less development of lean flesh, and average somewhat less in weight. While the percentage of carcass weight in loins and ribs is frequently as high in heifers as in steers, the greater thickness of lean meat in those parts of the steer is greatly to his advantage. Further, the tendency in heifer beef is to carry the fat more largely in the form of kidney suet or "gobby" fat than steers in the same degree of finish; they are also flatter in the loin, fatter in the plate and more "necky" than steers. Accordingly heifer beef is rated lower in the market than steers of corresponding grades. The average heifer carcass is lighter in weight and lower in grade than the average steer. Experts are not agreed as to the comparative quality of the two classes of beef, and it may be said that differences in color, texture and "substance" of flesh are not marked. The prevailing notion that heifer beef is in relatively higher favor in England than in America is true only so far as the best grades are concerned. Heifer sides differ from cows in their immaturity, indicated by softer bones and brighter color of flesh; in shape, especially their less angular rumps, fuller loins, and shorter necks; and in their smoother finish and smaller, firmer bags. Heifers are sold principally in the side or quarter, owing to the demand for this beef for retail butcher trade. A considerable proportion of this class are *yearlings* (page 186), averaging 400 to 600 pounds. The regular run of heifers weigh

350 to 750 pounds, and are graded *Prime, Choice, Good* and *Medium*.

Prime heifers are selected according to practically the same requirements as prime steers, with special reference to full loins and rounds, compact form, smooth finish, short neck and light udder. They seldom have quite the thickness of flesh found in steers. The few carcasses of this grade which appear in the mar-

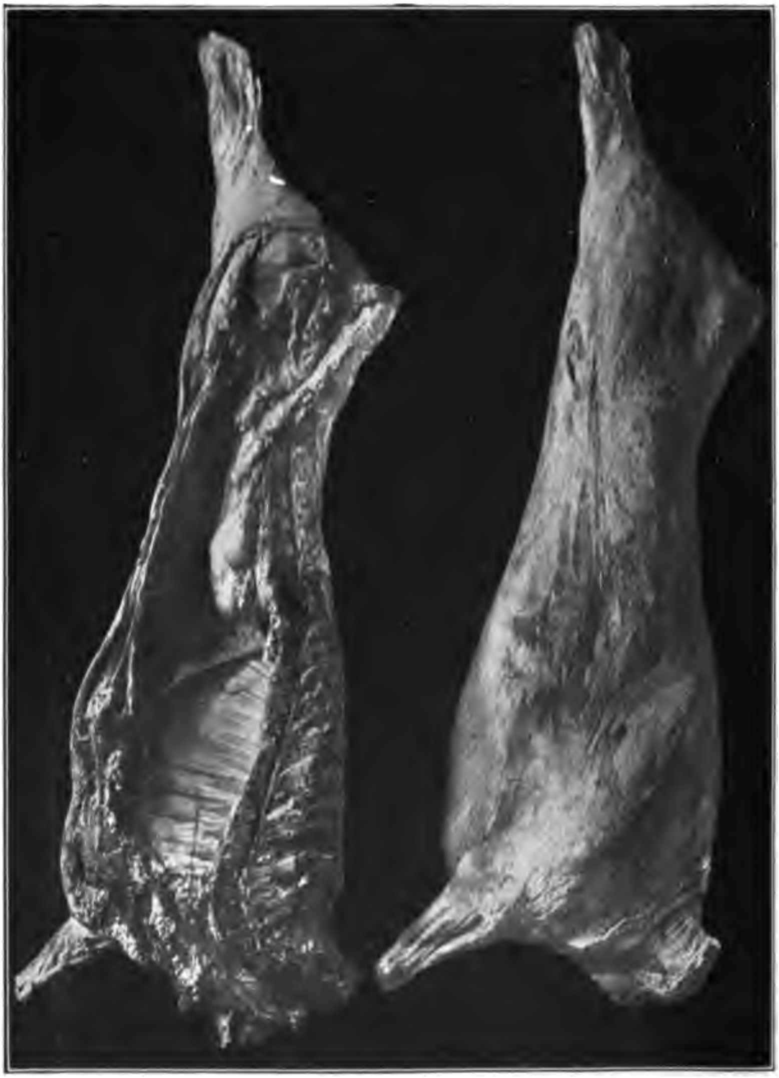

FIG. 7. PRIME HEIFER.

kets are usually seen in lots of choice and prime bullocks, in which case they may sell at a uniform price with the latter. When sold separately they are discriminated against by most American dealers, on the ground that the steaks and roasts do not cut out as thick in the lean as those cut from steers and that the proportion of waste fat is greater. Since this discrimination is not made in British trade, owing to its greater demand for fat steaks and roasts, prime and choice heifer carcasses are frequently exported. See Fig. 7.

Choice heifers are similar to choice steers except in the points mentioned in the preceding paragraph. As a class they are imperfect in finish and quality rather than in form and thickness as compared with prime heifers. Like the latter, they must be strictly "maiden" heifers; that is, the carcass must bear no evidence of pregnancy. They are sold to city and country retail dealers, shipped east, and occasionally exported to Great Britain. See Fig. 8.

Good heifers. These are sides that are clearly above the average of the class but lack either the finish, thickness or conformation, or all, required of a choice side. They must have sufficient covering and kidney fat to show that they have been fattened on a grain ration. Local retail dealers use a great deal of this grade of beef and much of it is shipped to the smaller cities. See Fig. 9.

Medium heifers. The medium or average heifer carcass is plain in conformation and deficient in flesh and finish. A marked deficiency in either of the three points renders a side *medium* which would otherwise grade *good,* and many of this grade are of the heavy weights (700-800 pounds) and somewhat "cowish" in general appearance. They are the lowest grade of heifer sides that can be entirely sold over the block of the ordinary retailer, and are to some extent made into wholesale cuts before being sold by the killer. This beef supplies the second class trade of which most retailers have more or less, and is used for the bulk of the trade in cheaper markets. See Fig. 10.

Common heifers. Common heifers have little covering of fat and only sufficient thickness of flesh to be used as cutters. This grade also includes many heavy heifers which are still more "baggy" and "cowish" than medium heifers. In fact little distinction is made between common heifers and cows as the differences are much less apparent than in higher grades, and in many cases are quite immaterial. (Fig. 11.) Very few heifers are found among canners, and those that are so found are well represented by the illustration and description of canner cows.

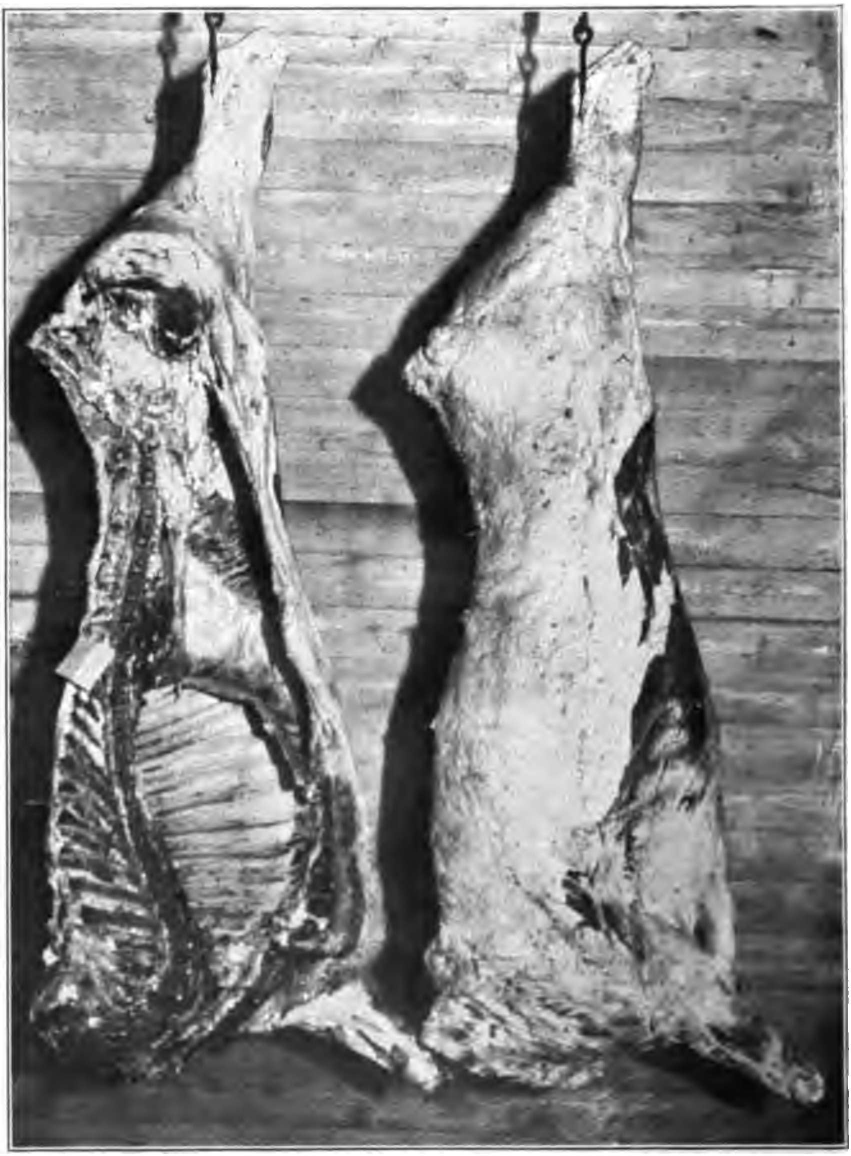

FIG. 8. CHOICE HEIFER.

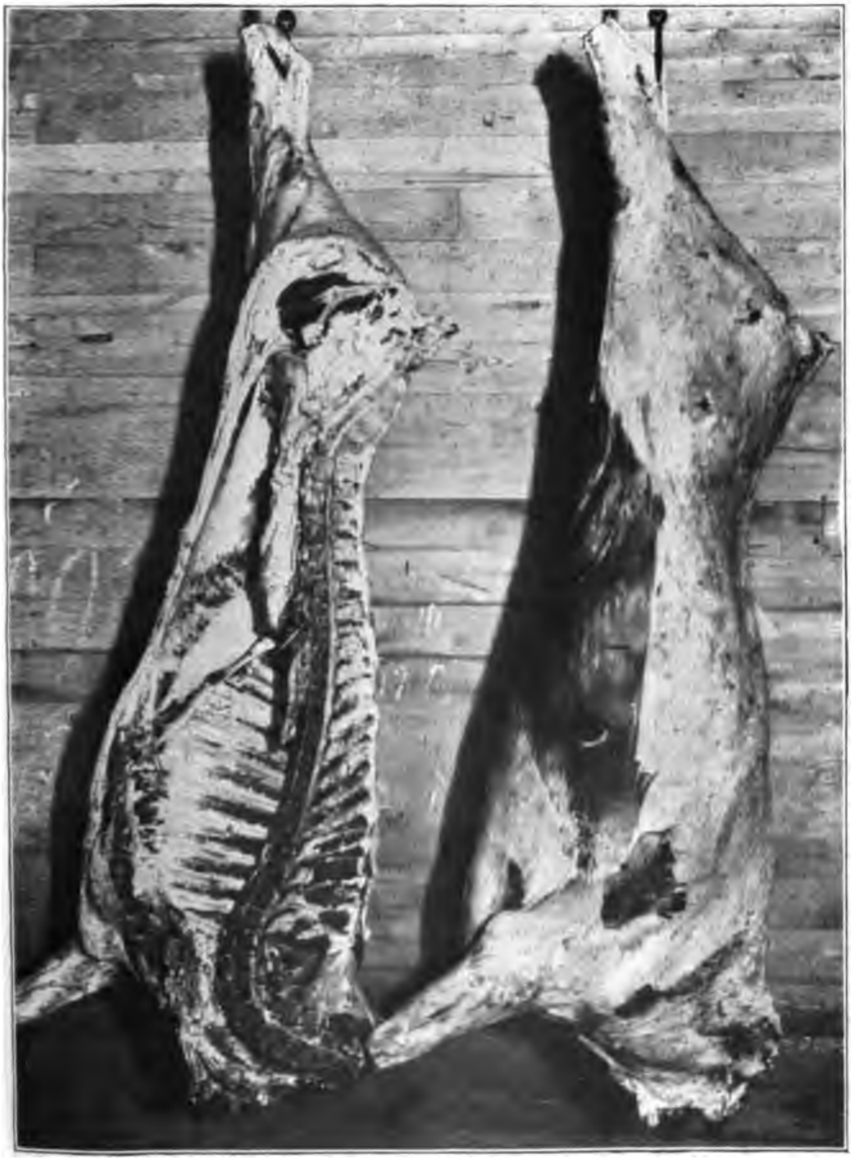

Fig. 9. Good Heifer.

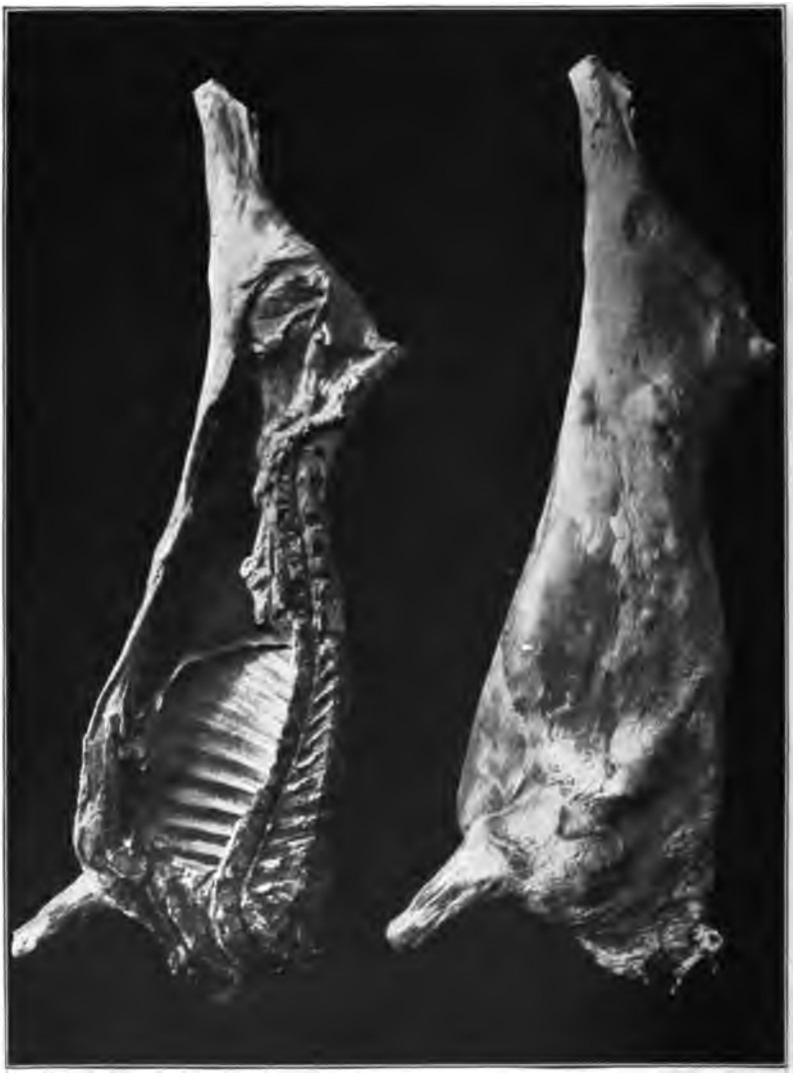

FIG. 10. MEDIUM HEIFER.

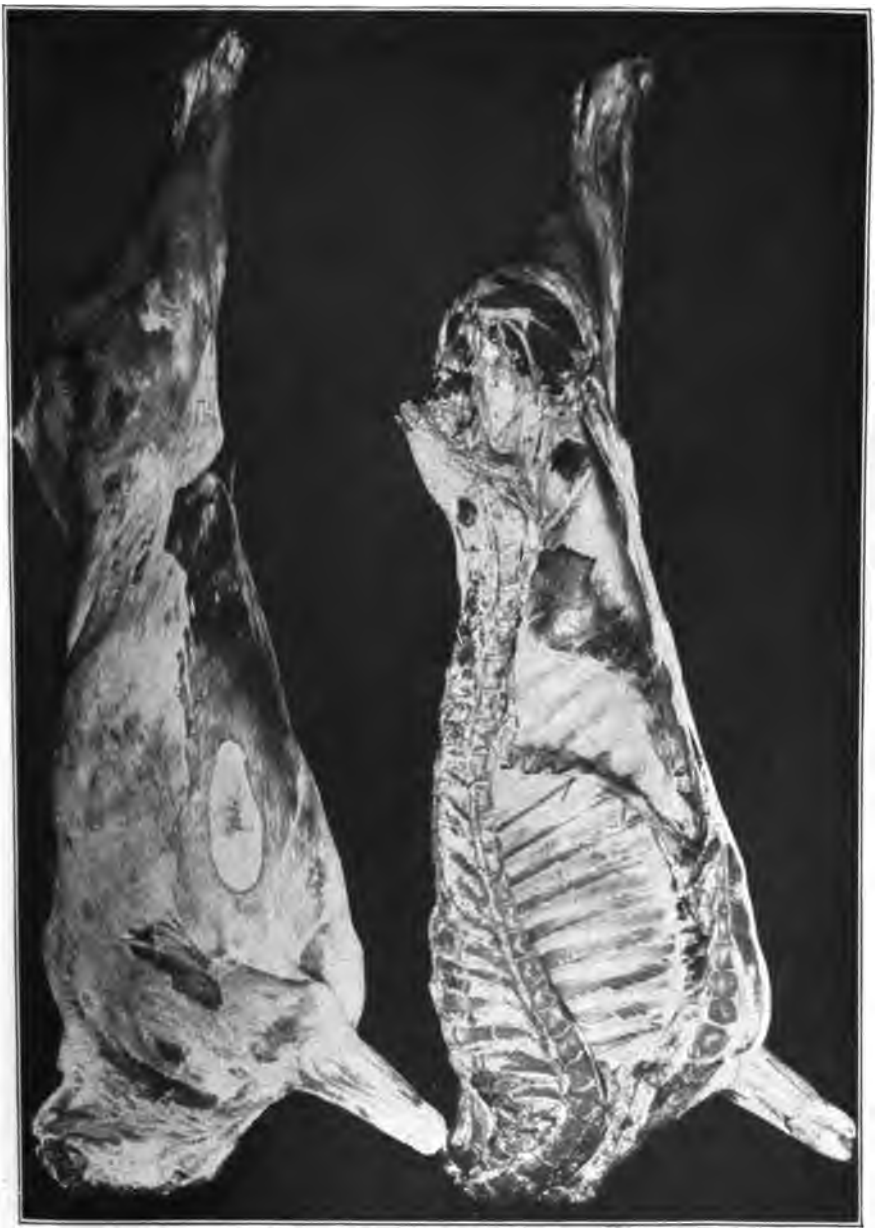

FIG. 11. COMMON HEIFER.

Cows

The angular form, long neck, hard, white bones and lack of thickness of the majority of cow carcasses make them easy to distinguish from other classes of beef. The bag is trimmed off as closely as possible in dressing cows but it is generally large and "baggy" enough to indicate the class of the carcass. The bones are also hard and therefore do not split as smoothly as heifers or steers, especially at the chine and loin. Fat cow carcasses often carry their tallow as kidney fat and in bunches on the back and rump rather than an even covering; and the flesh is seldom as well marbled as that of heifers or steers. Fat is especially important in cows because such beef generally requires "ageing" or ripening to render it tender, and good covering is essential for this purpose. A large percentage of the carcasses of this class are cutters and canners, with a correspondingly smaller proportion suitable for "side beef". Cow sides which have the amount of fat required in prime steers and heifers are as a rule either crusty or lumpy, so that no prime grade is recognized in the markets. The grades are *Choice, Good, Medium, Common* and *Canners.* Choice cows average 600 to 900 pounds, canners 250 to 500, and other grades accordingly. Many of the heavy weights, however, are graded lower than choice on account of waste fat.

Choice cows have as much fat as choice heifer sides but are not usually as good in shape nor thickness, the loin being flatter, neck and shanks longer and rump more prominent. They are less numerous than the same grade of heifers, and the few that come into the markets are seen mainly during the fall and early winter. Too much age, lack of loin and rib covering, lumpy fat and a heavy bag are defects each of which bar many carcasses from this grade. Choice cows are taken in the carcass by a good class of retail trade, and are also cut up to quite an extent in wholesale markets for No. 1 loins and ribs. See Fig. 12.

Good cows. This grade is above the average of cow sides in general quality. Deficient finish is found in all cow beef grading below *choice,* but kidney fat and outside covering are not entirely lacking in either the good or medium grades. Good cow sides are chiefly used for the cheaper trade of retail markets. See Fig. 13.

Medium cows. While these carcasses have the quality and covering necessary in a low grade of dressed beef, they are better adapted to the cut beef trade and are generally so used. Medium cows must have a moderate amount of kidney fat and a slight covering over the ribs, loin and rump. Many of them are plainly

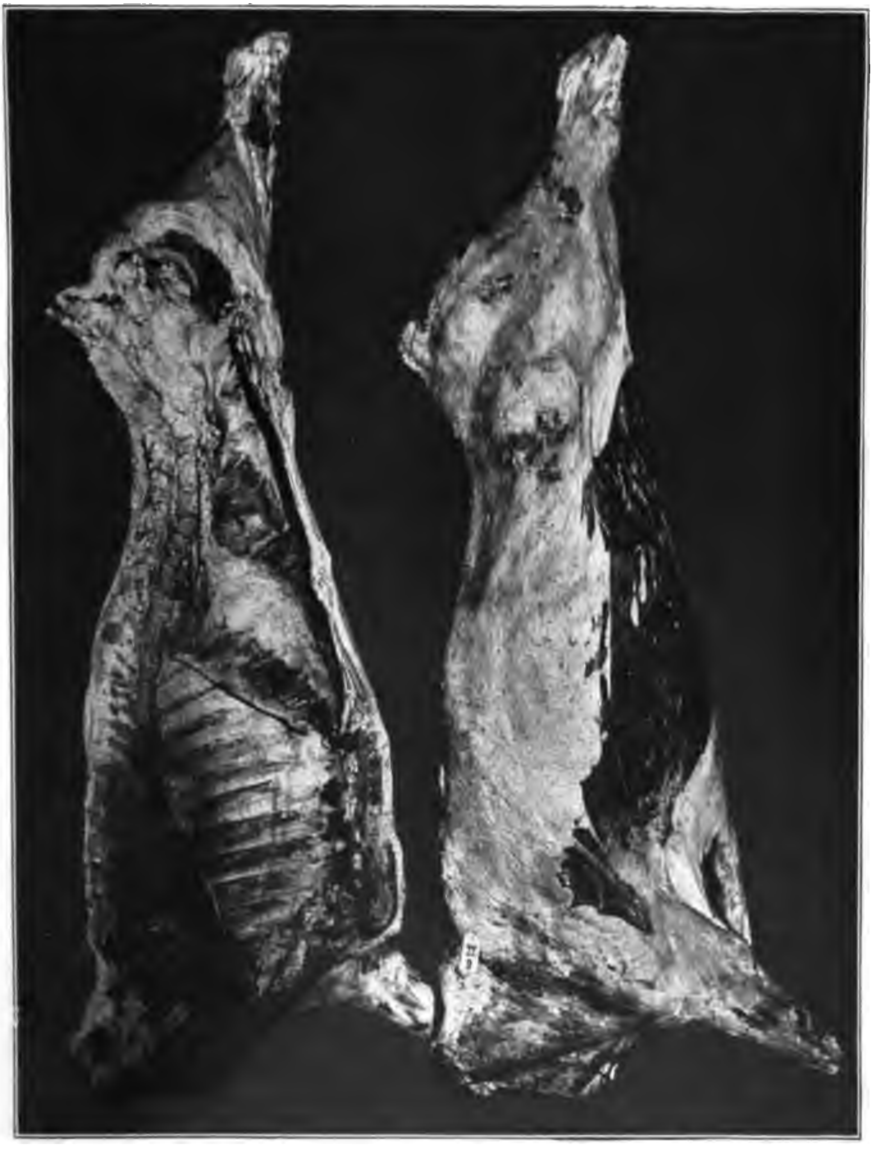

FIG. 12. CHOICE COW.

deficient in thickness of flesh, especially over the loin and ribs, are rougher about the hips and rump, lighter in the rounds and longer in the neck than good cows. See Fig. 14.

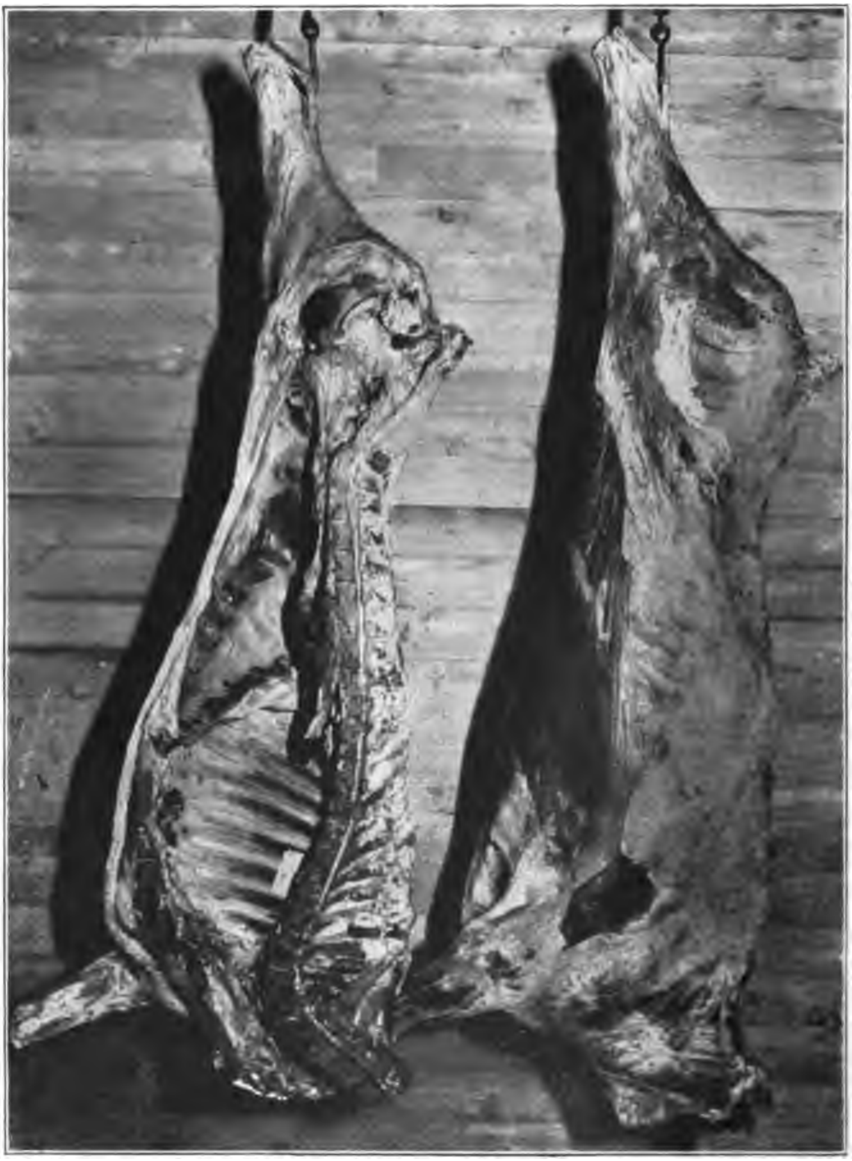

FIG. 13. GOOD COW.

Common cows. These are inferior in conformation to steers of the same grade, being on the "shelly" order, i.e., poorly fleshed, bare on the ribs and warped in shape, showing the effects of repeated pregnancy. They are very prominent at hips and rump, nearly devoid of covering and kidney fat, white and flinty in bone and decidedly wanting in thickness. This grade also includes a few carcasses that are medium to good in thickness and shape but

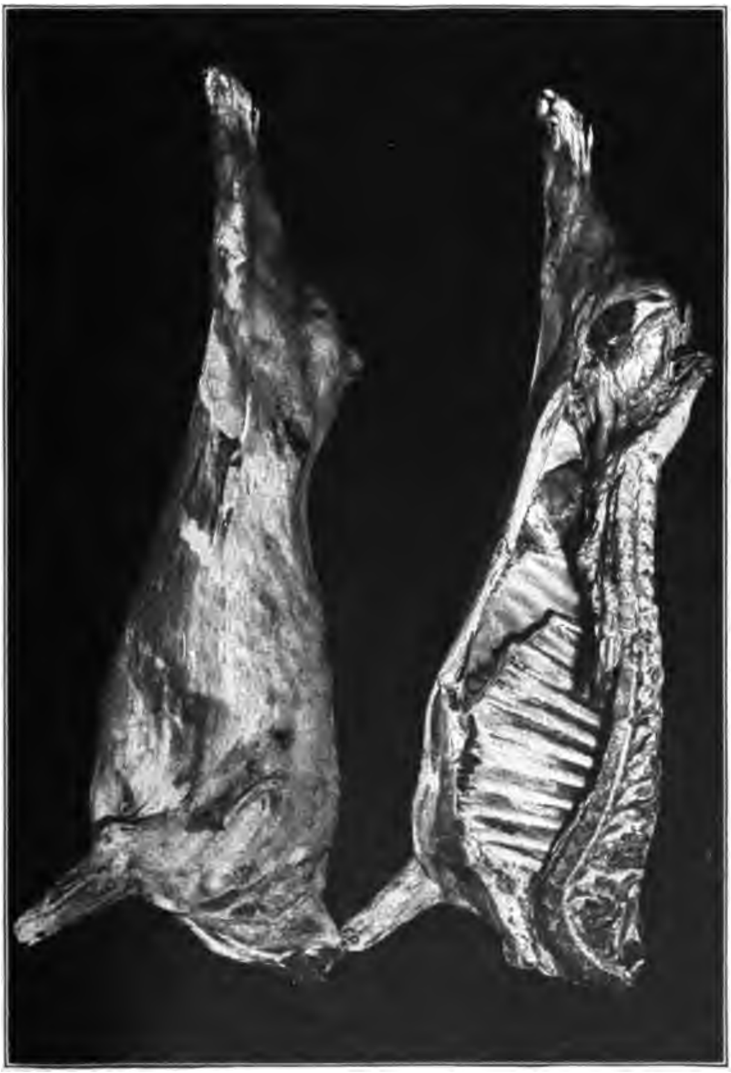

FIG. 14. MEDIUM COW.

inferior in color, finish or general quality. They are used principally as cutters and for stripped and frozen cuts, barreled beef, etc. See Fig. 15.

Canner cows are the lowest grade of this class, and make up the bulk of the beef used for canning purposes. Typical canner sides have no covering, no kidney fat, and in most cases only sufficient flesh to hold the bones together, so that the shape of such carcasses is of the most inferior order. The flesh is generally very

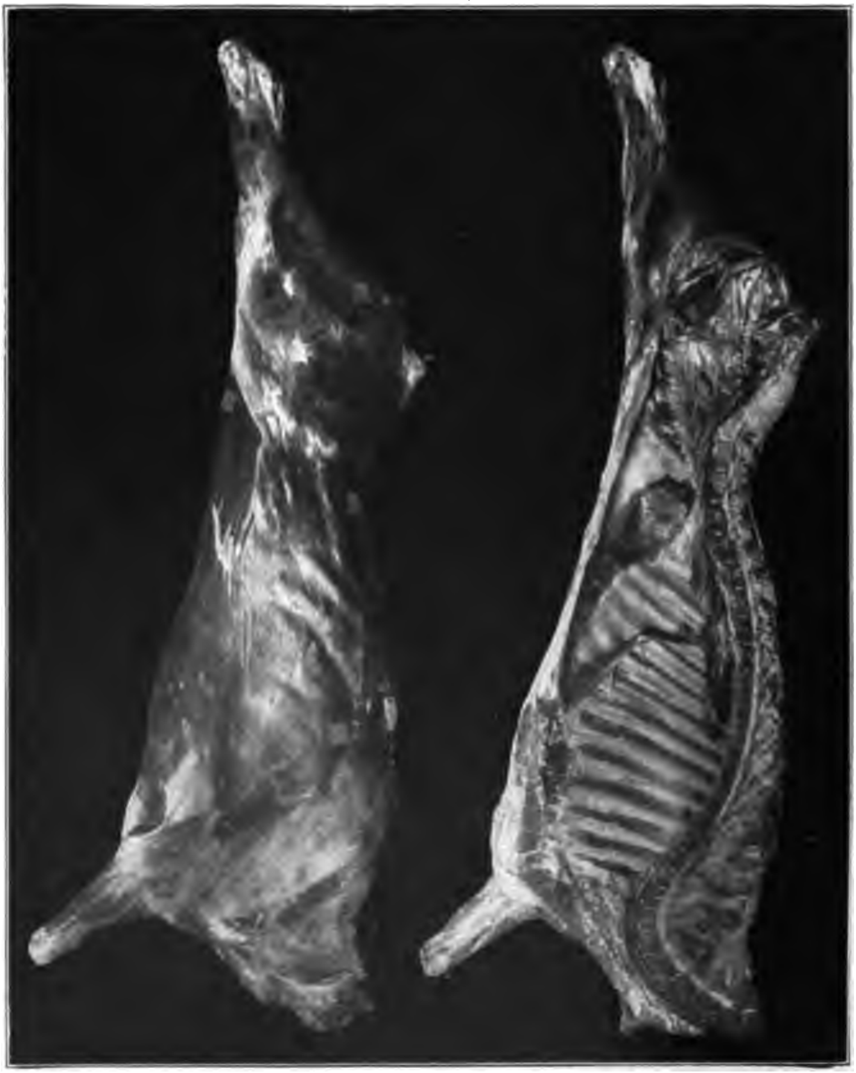

FIG. 15. COMMON COW.

dark in color. This grade, as well as the one above it, also contains many bruised sides, some of which are otherwise medium. About one-third of the carcass is used for canning and sausage purposes, and the remainder is "stripped" and sold in the form of boneless fresh beef cuts and barreled beef. See Fig. 16.

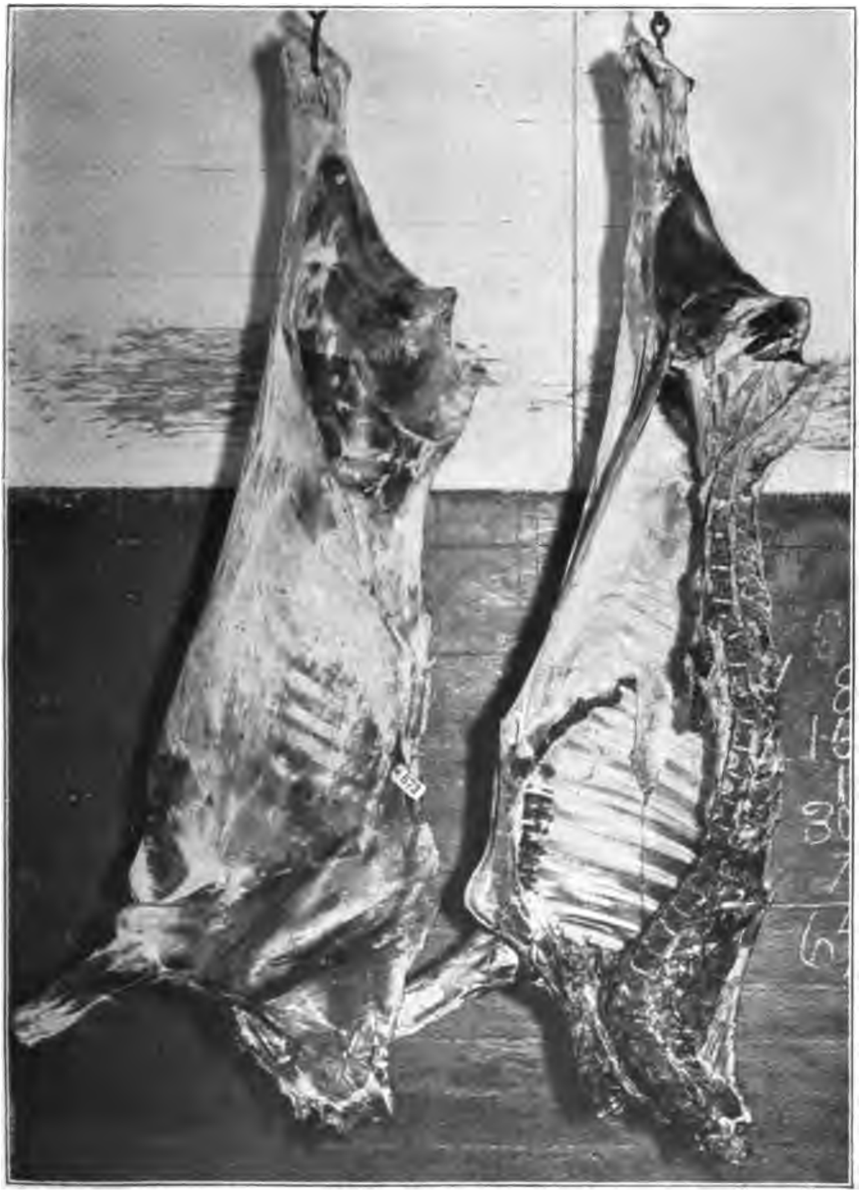

Fig. 16. Canner Cow.

BULLS AND STAGS

Dressed bulls are easily recognized by the prominent neck, heavy shoulders, thick rounds, dark color, coarse-grained flesh, and the absence of cod fat. Rough conformation and hard bones are also common characteristics of bull sides. Bruises, bad color, and "bone-sour" account for the low grade of many bulls and

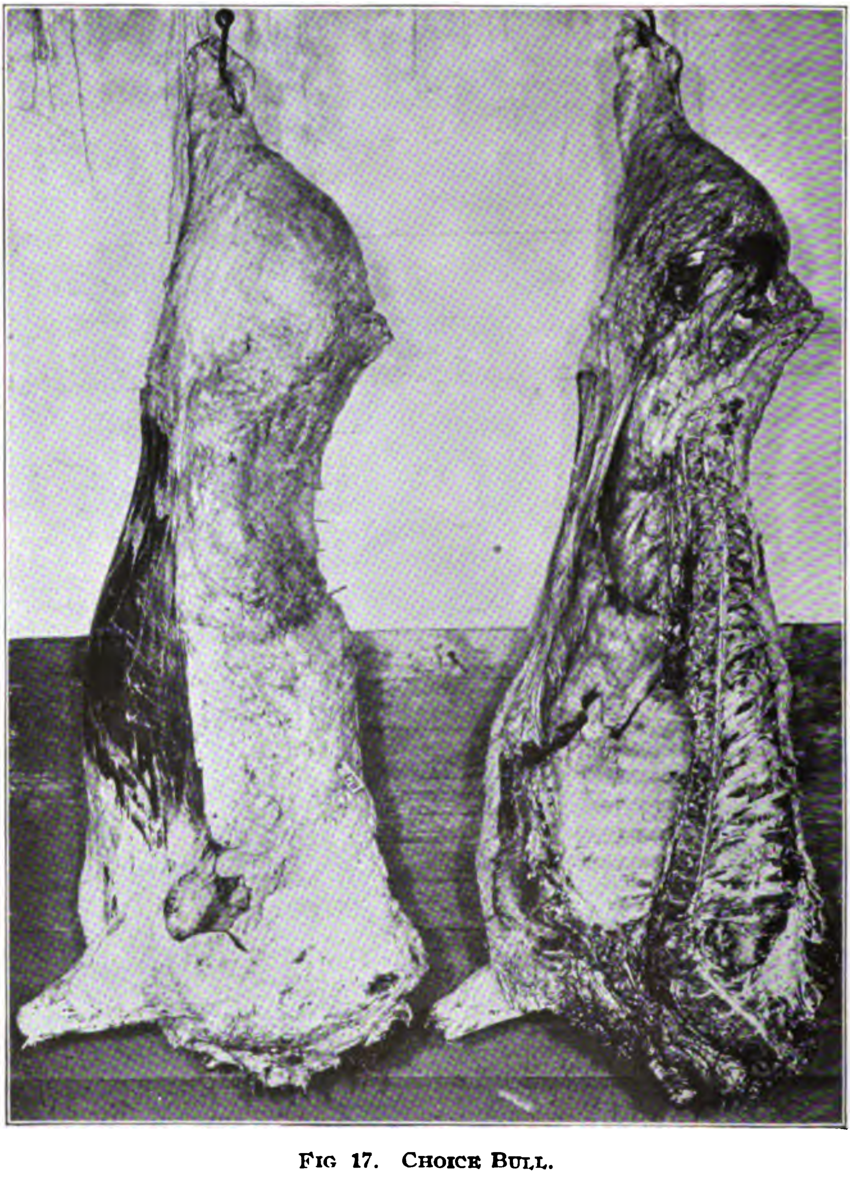

FIG 17. CHOICE BULL.

stags. Many stags approach steers in form, quality and finish, while others are difficult to distinguish from bulls. Altho various grades of beef are found in this class, the proportion of medium and lower grades is much larger than in the steer and heifer classes, and comparatively few bull sides are adapted to the dressed beef trade. As a class bulls have dark coarse flesh with no marbling, which when made into sausage, absorbs a large percentage of water, and when smoked shrinks but little. Hence the majority of bull carcasses in the market are partially used for sausage, and the rounds made into smoked beef hams. The class is for the most part deficient in covering and finish, tho in thickness of flesh bull sides as a class are decidedly superior to cows. The regular grades are *Choice, Good, Medium* and *Common.* In weight, choice carcass bulls average 900 to 1200 pounds, common bulls 550 to 800, and other grades in proportion, tho in some cases the grade is quite independent of the weight.

Choice bulls resemble good to choice steers in thickness, color and maturity, but are heavier in neck and rounds, and the finish is never equal to that of steers of choice grade. Occasionally, however, a choice stag carcass is seen which is very difficult to distinguish from a steer. 700 to 900-pound bulls of choice quality are used by some retail butchers for their cheap trade, and can be so used to best advantage during the colder months, when boiling meat is more in demand than in the warm seasons. Even this grade of bulls, however, can ordinarily be cut up with more profit to the wholesaler than can be realized by selling them in sides or quarters, because wholesale cuts do not bear as much evidence of the sex and general quality of the carcass as beef in the side. There is also a considerable export trade in choice and good carcass bulls of heavy weights. See Fig. 17.

Good bulls. This grade is distinguished from choice bulls by deficiencies in quality, conformation and color. To grade good, however, a bull carcass must be moderately fat and smooth and not too coarse nor dark-colored in flesh. A very small proportion of good bulls sell in the carcass to the cheapest dressed beef trade but they are principally utilized for beef cuts, both "straight" and boneless, and the cheaper parts of the carcass for sausage and smoked or barreled beef. See Fig. 18.

Medium bulls. Sides of this grade often have the muscular thickness required in side beef but lack sufficient covering of fat. They are rougher in appearance than good bulls and are usually characterized by coarse flesh, hard white bones, and very heavy necks and rounds. Some of the ribs and loins go to a cheap class of restaurant trade, and the other parts are largely used as barreled and smoked beef. When common bulls are scarce medium grades are more largely used for cured beef products. See Fig. 19.

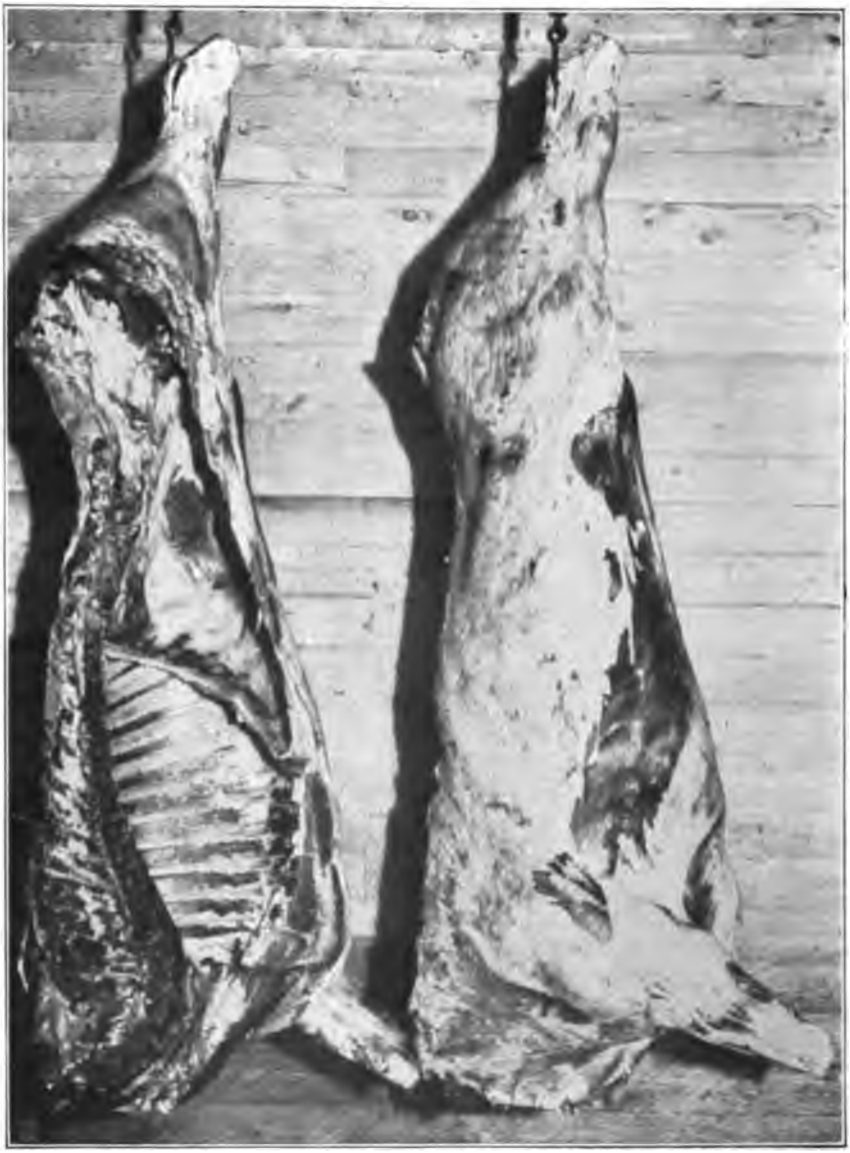

FIG. 18. GOOD BULL.

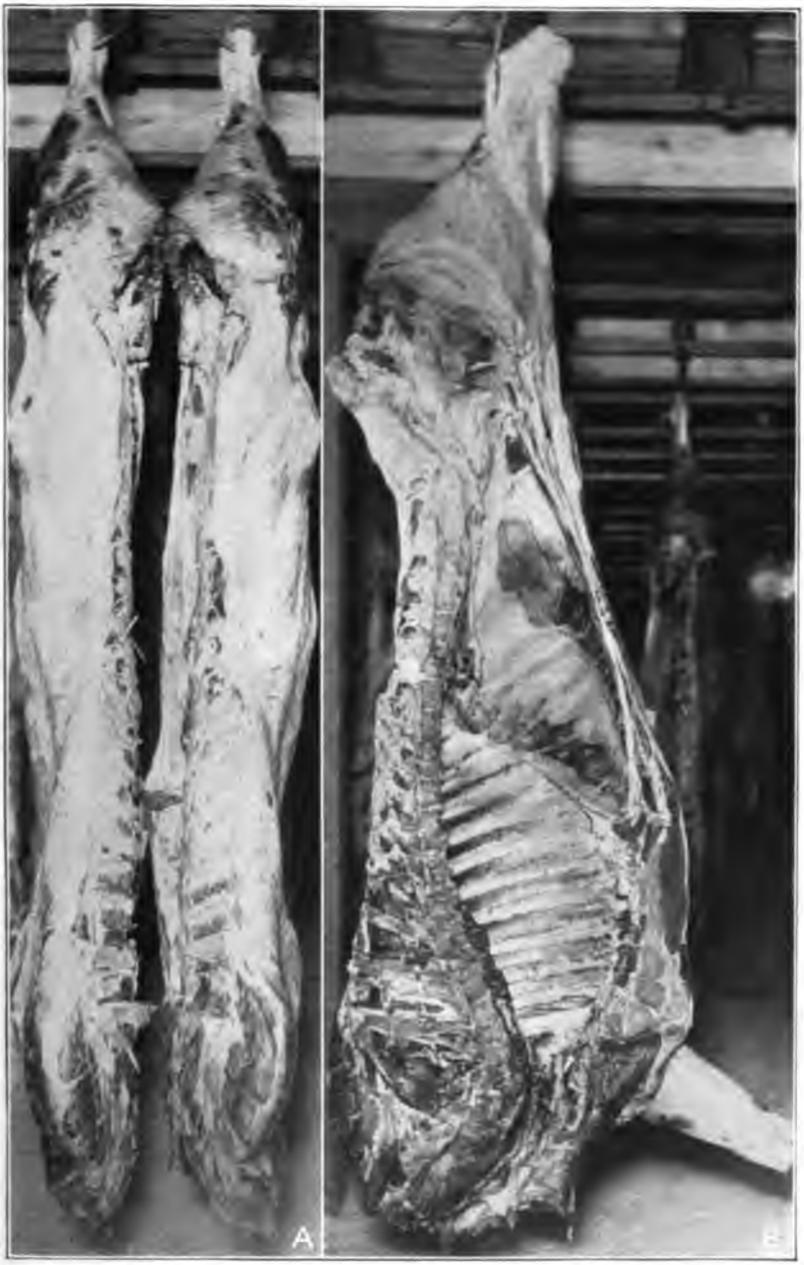

Fig. 19. Medium Bull.

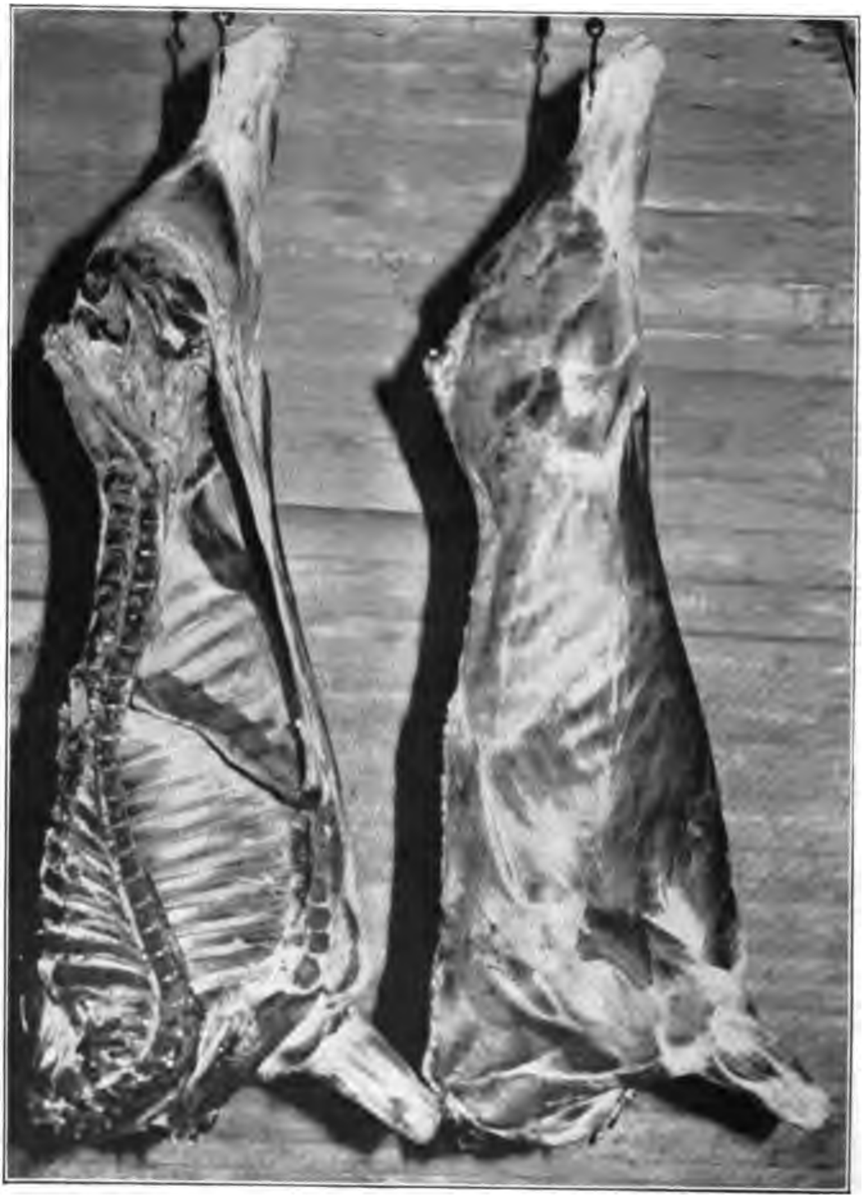

FIG. 20. COMMON BULL.

Common or Bologna bulls. Bull carcasses which have no covering of fat and are plain or rough in form but still fairly thick fleshed are known as *bolognas.* They include many bruised sides, and most of this grade are very dark in color and flinty in bone. The lean and dry nature of these carcasses adapts them to the manufacture of bologna sausage and dried beef. A considerable proportion of such sides also yield ribs and loins which can be sold straight or stripped. They average 600 to 900 pounds. See Fig. 20.

A small percentage of the supply of dressed bulls and stags grade as canners. The description of canner cows applies in all essential points to the corresponding grade of bulls, and their use is similar.

"Native", "Western" and "Texas" Beef

In connection with the preceding classification, carcass beef may be further designated as "Natives", "Westerns" or "Colorados", and "Texas". These terms are used in the same sense, tho scarcely to the same extent, in the beef trade as in the live cattle market. The distinct differences which formerly separated them have become much less marked in recent years owing to improvement in quality of beef produced in the West and Southwest. It must be understood that these names do not apply to all beef marketed from the section or state indicated. They are sufficiently distinct, however, to give each term a reasonably definite meaning in market circles; and they are sometimes applied even to wholesale beef cuts (page 194).

"Native" carcass beef differs from "Western" principally in shape, finish, thickness and age. It is fatter and firmer in flesh, showing the effect of grain feeding; more compact in form, shorter in shanks and neck, thicker fleshed in loin, ribs, rounds and chucks, more mature in proportion to age and much better in marbling and general quality. Natives consist chiefly of medium to choice steers, heifers and cows of the heavier weights, but they include all grades of beef and are used either as dressed beef, cutters or canners. They make up over 85 percent of the carcass beef trade at Chicago.

"Westerns" or "Colorados" are carcasses that are comparatively "rangy" or loose-coupled in form, "grassy" or "green" in appearance. with coarser-grained flesh, larger, whiter bones, lighter kidneys, wider plates, more prominent shoulders and lighter, longer rounds than Natives. They do not run as fat as Natives, and most of them are "hipped' or bruised on the plates and ribs. The flesh just underneath the shoulder blade is almost invariably dark colored, as is observed when the chuck is taken off. The rump bone is generally thicker and more prominent than in Natives. Heavy, well-finished "Colos" or "Collies", as they are called by salesmen, frequently yield loins and ribs that can be substituted for those of Natives. By far the greater proportion of carcasses in this class are medium and common grades, with a considerable percentage of cows, and a smaller proportion of heifers than in Native cattle. Heavy steers (750 to 1000 pounds) of this description are usually termed "Colorados" and the 500 to 750-pound steers "Westerns". Western cows weigh 450 to 700 pounds. Most spayed heifers are Westerns; they are a very small percent of the number slaughtered, and little or no difference in price is made as compared with open heifers. The supply of Westerns is confined principally to the period from July to December, which is known in the beef trade as the "cattle cutting season". They are sold to a considerable extent as dressed beef, but are also cut up and stored in freezers in the form of No. 2 and No. 3 loins, ribs, rounds and chucks; also strips, rolls, clods, tenderloins, etc., and to some extent in quarters. These cuts are sold from the freezers mainly from Februray to June, when medium and lower grades of fresh beef are scarce. The plates, flanks and rumps are packed as barreled beef, and the rounds as "beef hams". "Colorado" beef constitutes only about 10 percent of the trade.

"Texas" beef refers to light-weight carcasses, more deficient in form and finish than "Westerns", and more "grassy" or "washy" in flesh, together with hard bone and dark color, showing considerable age. Many "Texas" sides are severely bruised due to long shipments of the live cattle. Large scars, resulting from branding the hide too deeply, are visible on the carcasses in some cases. They grade from canners to medium or good. Only 5 percent or less of the annual supply at Chicago consist of "Texas" beef, most of this beef being handled at Kansas City, St. Louis and Ft. Worth. It is in season from June to October. A larger proportion of this beef than of "Westerns" is cut for freezers. Both as carcass beef and as beef cuts it is taken mainly by small retail markets. The supply consists principally of three- and four-year-old steers and aged cows averaging as follows: light steers, 500 lb. or less; medium steers, 500-600 lb.; heavy steers, over 600 lb.; light cows, 400 lb. or less; medium cows, 400-500 lb.; heavy cows, over 500 lb.

"YEARLINGS", "BUTCHER", "KOSHER" AND "DISTILLERY CATTLE".

"Yearlings" are carcasses of young steers and heifers of 400 to 700 pounds dressed weight, with sufficient quality and finish to be used as block beef. Their immature age is indicated by light colored flesh and fat, and bones that split soft and red, especially

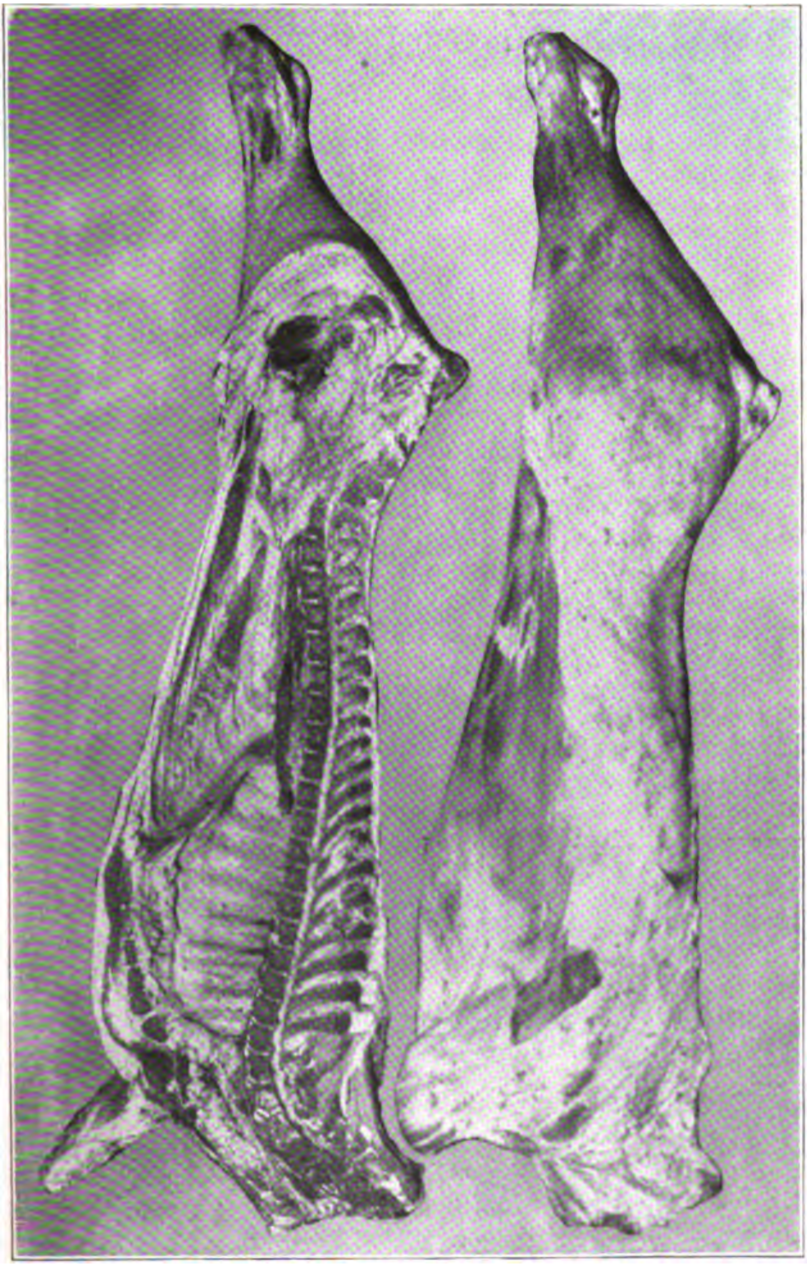

Fig. 21. Yearling (Good Steer).

the chine and brisket. They are graded *choice, good* and *medium*, and seldom have sufficient finish or maturity to be termed *prime*. The term *yearling* is applied more especially to good and choice young carcasses weighing 450 to 650 pounds. Thickly fleshed loin and ribs, short, compact body and high finish with one-fourth to one-half inch of fat on the back and some covering on the chucks and rounds are important points in choice yearlings. These cattle are in special favor with retail dealers who supply family trade, owing to the fact that they contain small but tender steaks and roasts with a small proportion of fat. See Figs. 7, 21.

"Butcher" Cattle, as the term is applied to carcass beef, are those which are suited to "butcher shop" trade. The typical retail meat market requires carcasses from which can be cut 1 to 1½-pound steaks and 4 to 6-pound roasts with no waste fat and of quality commensurate with a moderate price. The grades of carcass beef which yield such cuts are heifers, steers and cows of good, medium and common grades, averaging 400 to 700 pounds dressed weight. For the better class of trade, good and choice yearlings, especially heifers, are most in demand. Texas steers of the heavier weights are also used. The bulk of the city butcher trade, however, is supplied with light steers and heifers of medium to choice grades. Cows are largely cut up or sold to small retail markets.

"Kosher" cattle are dressed beeves that have been slaughtered, inspected, cleansed and labeled in accordance with Jewish rites, *kosher* being the Hebrew word for *clean*. The throat is cut without stunning the animal, the vital organs are specially inspected, and the carcass washed and labeled under the supervision of a rabbi. If not used within three days, the carcass is rewashed, and must be washed each three days until the twelfth day after. slaughter, when it is no longer "Kosher". Only the fore quarters are used by orthodox Jews, and the principal grades of cattle used for Kosher beef are medium to choice steers, cows and heifers. This trade is confined almost entirely to large cities, especially New York and Chicago. Under the restrictions imposed by Kosher rules, it is impracticable to ship this beef to eastern cities from Chicago and it is therefore a local trade, the eastern supply being shipped on foot.

"Distillers" are steers, bulls and stags that have soft, "puffy", "washy" flesh together with the "high color" that is characteristic of cattle fattened on distillery-slops. They are thick-meated and fat, but the flesh does not become as firm after chilling as that of corn-fed beef and the fat does not "set" as well owing to the soft feed and close housing employed in fattening and the consequent tendency toward a feverish condition of the carcass. The surface fat has a smooth, glossy, yellowish appearance. On cutting the fore quarters the flesh along the shoulder blades appears very dark. Distillers consist principally of good and medium steers and medium to choice bulls averaging 700 to 900 pounds. They are best adapted to the hotel and restaurant trade of large cities owing to their heavy weight, and a large proportion of the supply is shipped east. They are found in the market from April to June and a few thruout the summer months.

SHIPPING AND EXPORT BEEF TRADE

The fresh beef trade of eastern cities draws upon Chicago for all grades of carcasses described in the foregoing outline, but principally steers, heifers and cows of medium to prime grades. The demand in each city is as varied as the population, and with improved transportation and refrigerating facilities any grade of fresh beef can be delivered in good condition. Certain cities, however, are characterized by special demands which are recognized by the trade. Boston is the best market for very heavy fat steers, and discriminates less against excessively fat bullocks than any other city. The term "Bostons" is generally applied to such carcasses. Carcass beef shipped to Boston is quartered between the tenth and eleventh ribs. New York is celebrated for its extensive trade in Kosher beef, probably four-fifths of the beef koshered in this country being used in and near that city. This accounts for the large proportion of live cattle to dressed beef shipped from Chicago to New York, and for the large proportion of medium and lower grades in shipments of dressed beef to that city. Baltimore demands a comparatively large proportion of the lower grades of beef. Philadelphia, Pittsburg, Washington, Cleveland and Buffalo use an assortment of grades similar to that sold in Chicago. Refrigerator car-routes which supply small cities and towns thruout the country handle principally the grades of beef enumerated under "Butcher Cattle". Much low-grade beef is used in mining and lumbering districts, and orders from such districts are largely for strictly lean carcasses such as common light cows and bulls.

Export carcass beef consists chiefly of medium to choice steers. Heavy heifers, cows, bulls and stags of the good and choice grades are also exported. Bruised sides are discarded, and care is observed in testing for soundness, especially "bone-sour". Export cattle are dressed differently from domestic beef in that the sides are not scribed,* the hind quarter has three ribs, and the hanging-tenderloin and skirt are trimmed off. The quarters are wrapped separately in muslin. This trade has greatly diminished during recent years.

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*Scribing consists in cutting the chine-bones the length of the fore quarter on a line midway between the back-bone and the outer surface of the carcass. This permits the chine-bones to bend outward when the beef "sets", and gives the side a thicker appearance than otherwise.

BEEF CUTS

As previously stated, wholesale fresh beef trade is about equally divided between carcass beef and beef cuts. The latter are sold both as "straight cuts" and as subdivisions thereof. The "straight cuts" handled in Chicago markets are *Loins, Ribs, Rounds, Chucks, Plates, Flanks* and *Shanks* (Fig. 22). The loin is separated from the round at the hip joint. The flank is cut from about the middle of the thirteenth rib to the opposite lower corner of the loin. The shank is sawed off just below the second knuckle (shoulder joint). The plate is cut off on a line extending from about the middle of the twelfth rib thru the point at which the shank is removed. The rib and chuck are separated between the fifth and sixth ribs.

The standard grades of straight cuts are *No. 1, No. 2,* and *No. 3.* Cuts that are too deficient in thickness and quality to be used on the butcher's block, and which are consequently made into boneless cuts, barreled beef, sausage, etc., are termed *strippers.*

Grading Beef Cuts

The factors that determine the grade of a wholesale cut of beef are its *thickness, covering, quality* and *weight.*

Thickness of lean flesh is of self-evident importance. Consumers demand a large proportion of lean in steaks and roasts of whatever grade. Lean beef has a much higher market value than fat or bone, hence thickness of flesh is of first consequence, even in the cheaper cuts used for boiling and stewing. The depth of flesh is usually an indication of the class of beef from which a cut has been made, especially in distinguishing steer cuts from those of cows. The shape and general appearance of a cut also depend very largely upon its thickness.

Covering or depth of fat is most essential in the more valuable cuts, viz., the ribs and loins, because they supply the trade that is most particular in regard to quality of meat; and the highest quality of lean can be secured only at the expense of a liberal amount of fat. Those who are accustomed to buying round and chuck steaks expect little or no fat. As explained in referring to carcass beef, the lower grades are often entirely wanting in outside covering; and in second-class retail markets it is not uncommon to see ribs and loins, as well as cheaper cuts, from which the fat is conspicuously absent.

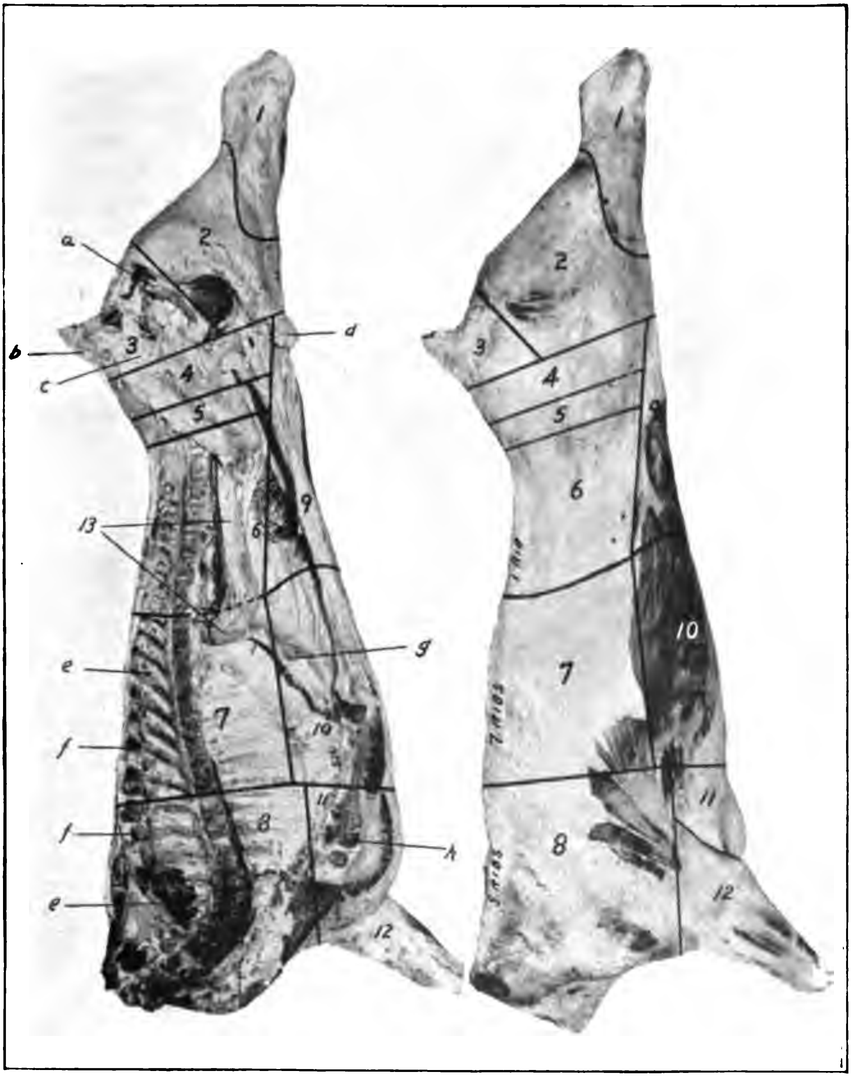

FIG. 22. BEEF CUTS.

1, 2, 3.	**Round**	1.	**Hind shank**	1, 2, 3, 4,		a.	**Aitch-bone**
4, 5, 6.	**Loin**	2.	**Round, R. & S. off**	5, 6, 9.	**Hind quarter**	b.	**Rump-bone**
7.	**Rib**	3.	**Rump**	7, 8, 10,		c.	**Crotch**
8.	**Chuck**	4, 5.	**Loin end**	11, 12.	**Fore quarter**	d.	**Cod**
9.	**Flank**	6.	**Pinbone loin**	7, 8.	**Back**	e.	**Chine-bones**
10, 11.	**Plate**	5, 6.	**Flatbone loin**	7, 10.	**Piece**	f.	**"Buttons"**
12.	**Shank**	10.	**Navel**	8, 11, 12.	**Kosher chuck**	g.	**Skirt**
13.	**Suet**	11.	**Brisket**	8, 10, 11, 12.	**Triangle**	h.	**Breast-bone**

Quality in beef cuts refers particularly to the grain and firmness of the lean, the marbling (distribution of fat thru the lean), and the proportion of bone and other waste in the cut. The grain of meat consists in its fineness of fiber or texture and the cut surface should be glossy, smooth or "velvety" in appearance and touch, as opposed to stringiness and coarseness. By firmness, in this connection, is meant "substance" or "body", as distinguished from a soft, gluey, or "washy" consistency of the flesh. It is an indication of tenderness, juiciness and maturity. On the other hand, firmness due to a dry, stringy condition of the flesh is objectionable. Ripening or "ageing"in the cooler improves the firmness, tenderness and flavor of beef, provided it is sufficiently fat. Very lean beef deteriorates rapidly after a few days in the chill-room. Frozen cuts sometimes develop a flabby or sloppy condition after thawing, due to the separation of the water from the tissues of the meat. This renders the cut tough and greatly detracts from its flavor. The importance of marbling consists mainly in its influence on tenderness. When fat is deposited in the connective tissue cells thruout the lean, the elasticity of the connective tissue is diminished, and the meat is improved in tenderness, juiciness, and flavor. Marbling is of special importance in ribs and loins of the higher grades, and is not usually evident in other cuts except the best No. 1 rounds and chucks. The proportion of bone directly affects the amount of edible meat in a cut and is therefore important. The bone is also a valuable indication of the age and class of the carcass from which the cut was taken. Coarse, hard bone is found in the same cut with coarse, stringy meat.

Color is of great importance in grading beef cuts, as it is an indication of the age and quality of the beef. The fresh cut surface of the lean should be a rich, bright red, and should turn brighter rather than darker after exposure to the air at refrigerator temperatures. A very dark color is an indication of either an old animal or a feverish or heated condition of the animal when slaughtered, and is also characteristic of cuts taken from bulls and stags. Exposure in a warm atmosphere, however, will produce a dark color on the surface of beef of any grade. A very pale or pinkish tinge, on the other hand, usually indicates immaturity. Cuts showing dark spots in the lean are placed in the *No. 3* and *Stripper grades.* The fat should be a clear white. In the lower grades it varies from white to yellow.

Weight affects the grade of a beef cut in the same manner and to about the same extent as in the grading of carcass beef. Altho the higher grades are made up largely of heavy cuts, a light cut may grade No. 1, if it complies with all other requirements of that grade, and a heavy cut is graded No. 2 or No. 3 in case of deficiency in thickness, quality or color. The heavier weights of each grade are cut from steer sides, and from stags and bulls to a small extent in the No. 2's and No. 3's, while the light cuts are largely from cows. For example, No. 1 cuts are principally from choice and prime 800 to 1000-pound native steer carcasses and choice 750 to 900-pound native cows; No. 2's are largely from medium and good 650 to 800-pound steers and 600 to 750-pound cows; and No. 3's are made chiefly from 450 to 600-pound common and medium cows, also from Texas and light Western steers. Stripper cuts are made from canners, medium and common bulls, Texas and common light Western cattle.

Average Weights of Straight Beef Cuts (Pounds)

Grade	Loins	Ribs.	Rounds	Chucks	Plates	Flanks	Shanks
No. 1	50-85	30-50	75-110	75-110	40-80	15-20	10-20
No. 2	40-60	25-35	60-80	60-80	30-50	10-15	5-10
No. 3	25-40	20-25	40-60	40-60	20-35	5-10	
Strippers	20-30	15-20	30-40	30-40	15-20		

Relative weights of the above cuts vary slightly in different markets according to the method of cutting and are varied more or less with changing market prices of the different cuts. The following table represents (1) the range of these variations and (2) the percentages that are commonly used in estimating the cutting yield of side-beef:

Percentages of Wholesale Beef Cuts to Carcass Weight

Cuts	Loins	Ribs	Rounds	Chucks	Plates	Flanks	Shanks	Suet
Extreme range	15-19	8-11	20-26	21-27	12-16	2-5	3-7	2-7
Conventional average	17	9	23	26	13	4	4	4

In general, a high finish indicates a relatively large percent of kidney-suet; carcasses of the higher grades contain a smaller per cent of kidney suet than lower grades if equally fat; and cows and heifers yield a larger percent of kidney suet than steers of the same grade. Otherwise the various classes and grades of carcass beef are similar in relative proportions of different cuts; and the above variations are caused mainly by the method of cutting and by individual characteristics of different carcasses.

The relative market value of these cuts correspond to the order of their arrangement in the above tables, excepting suet, which is more variable. For the purpose of mental calculations as to the cutting value per pound of side-beef, a carcass is regarded as consisting of four parts which are approximately equal in weight, viz., (1) loins and ribs, (2) rounds, (3) chucks, and (4) plates, flanks, shanks and suet. By averaging the market prices of the four divisions the value per pound of a carcass can be very closely estimated. Similarly, "hinds" are regarded as consisting of 50 percent round, 35 percent loin and 15 percent flank and suet; "fores", 50 percent chuck, 20 percent rib and 30 percent plate and shank.

It is customary in quotations of beef cuts to differentiate between steer and cow cuts; e.g., No. 2 steer loins and No. 2 cow loins. This distinction is readily recognized in the cuts by their shape, bones, thickness, quality and color as explained in reference to carcass beef. Heifer cuts are seldom quoted, owing to the demand for heifer beef in the side. "Native" and "Western" cuts are sometimes specified in quotations of No. 1 and No. 2 cuts and are distinguished by the characteristics described on page 185. In the No. 3 and stripper grades of cuts little or no distinction is made between Native, Western and Texas beef.

LOINS

The loin is the highest-priced cut of the carcass because of the tenderness and quality of the lean. The grade of a loin may be determined by marked excellence or deficiency in either thickness, covering or quality, or by a uniform degree of development in all respects. No. 1's must have a full, well-rounded shape, a complete covering of white fat the thickness of which is in proper proportion to the lean, and bright, firm, fine-grained, well-marbled flesh. No. 2's are generally less rounded in form, with insufficient, excessive, or uneven covering and a slight deficiency in grain, marbling or color of flesh; while No. 3's are more flat in shape, nearly or entirely lacking in covering of fat and very deficient in thickness and quality of flesh, but sufficiently developed to be cut into porterhouse and sirloin steaks for cheap trade (Fig. 23). Stripper loins have no outside fat and are usually extremely flat and rough in shape, with dark-colored, coarse-grained flesh and hard, white bone.

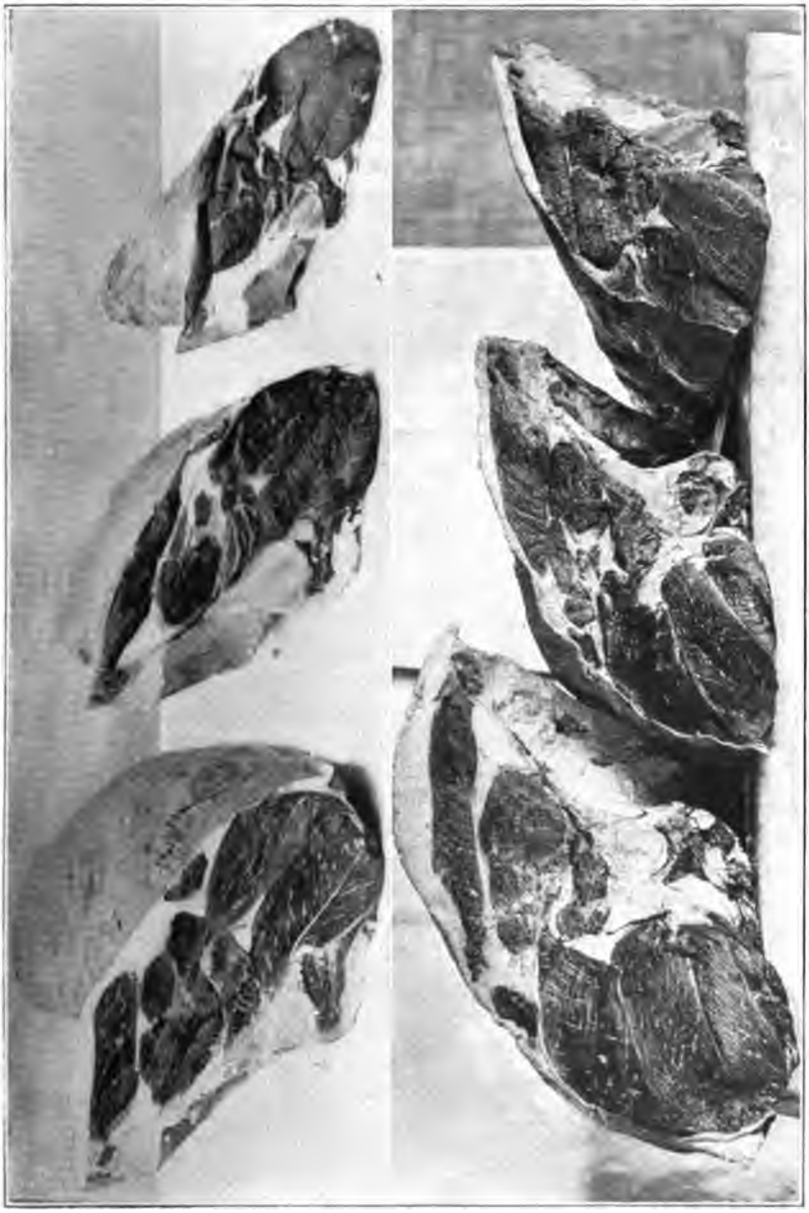

FIG. 23. A, FLAT BONE LOINS, NO. 1. NO. 2 AND NO. 3 GRADES.
B, REGULAR LOINS, NO. 1, NO. 2 AND NO. 3 GRADES.

Several different cuts of the loin are used extensively as wholesale cuts, particularly in the No. 2 and 3 grades. The regular or pinbone short loin is the portion between the thirteenth rib and hip-bone (pinbone) inclusive and includes from 45 to 55 percent of the full loin. It contains porterhouse or T-bone, and club steaks, and is valued at 40 to 60 percent more per pound than the full loin. This cut is made in 3 grades, the weights of which run from 20 to 40 pounds. The remainder of the full loin is called the loin end and is valued at about one-third less per pound than the full loin. It is used for sirloin steaks.

If the short loin is cut off midway between the pinbone and butt end of the loin it is known as a flatbone short loin. It sells lower than the pinbone loin, and is considerably used in Chicago markets. It is also graded No. 1, 2 and 3, and is made in averages from 20 to 45 pounds.

The tenderloin ("beef tender" or "fillet of beef") is a long muscle lying between the kidney-fat and the back-bone and extending from the thirteenth rib to the butt end of the loin. As the name implies, it is a very tender piece; and the great demand for it, notwithstanding its lack of juiciness and flavor compared with other parts of the loin and rib, is a striking example of the importance of tenderness in the estimation of beef customers. The tenderloins required to supply the demand are taken principally from No. 3 and stripper loins. They weigh 2 to 8 pounds. No. 1's must weigh above 6 pounds and have a bright color. No. 2's weigh 4 to 6 pounds; No. 3's, 3 to 4; and "strip tenders" or "shoestrings" less than 3 pounds. No. 1 tenderloins command about twice the wholesale price paid for the lowest grades. See Fig. 30.

Loins from which the tenderloin has been removed are called *strip loins* or *strips* (Fig. 24). They average 7 to 15 pounds and are graded mainly according to weight. Strips are usually cut into the *sirloin strip*, or stripped short loin, and the *sirloin butt*,

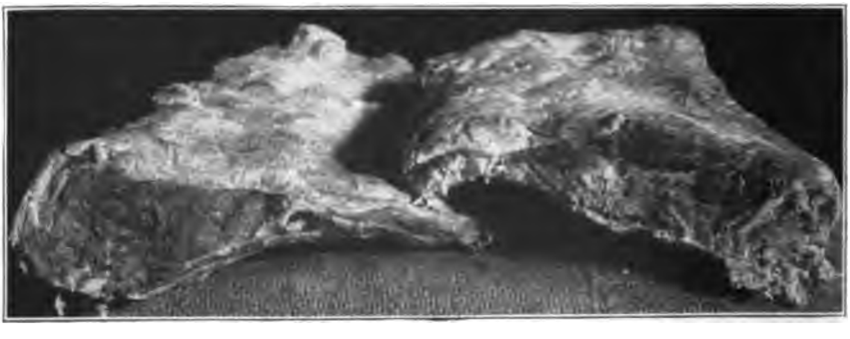

FIG. 24. FROZEN STRIP LOINS, NO. 3 GRADE.
Front View. Rear View.

which is virtually a stripped loin end. The lowest grades of strips and butts are often boned out, in which case they are known as *boneless strips* and *boneless butts,* respectively. They are almost entirely used for cheap restaurant and hotel trade to be cut into small steaks. Large quantities are frozen during the cutting season. Strips and butts are sometimes made from No. 3 as well as "stripper" loins, and include many from bulls and stags. Boneless strips average 4 to 8 pounds, and are occasionally made in averages as high as 10 to 12 pounds. Butts weigh 3 to 6 or 8 pounds.

RIBS

This cut, which includes the portion between the loin and chuck, is also known as the prime or standing rib. As the loin contains the choicest steaks, the rib contains the best roasts. Ribs and loins are commonly sold in sets at a lump price. Quoted separately, ribs are valued at 10 to 20 percent less per pound than loins of the same grade, due to difference in quality of the lean and larger proportion of bone in the rib cut.

The various grades of ribs differ in thickness, covering and quality to the same relative extent as the corresponding grades of loins. The depth and quality of flesh are apparent in the "eye" or "heart" of beef at the twelfth rib and in the cut end next to the chuck. The covering of fat on No. 1 ribs should be about one-half inch in depth. The bones in this cut serve as a very valuable index of the quality of beef, the chine-bones and ribs varying according to age as explained under *carcass beef,* and the "feather edge" of the shoulder blade indicating the age of the carcass in like manner. The latter is cartilaginous in young animals and is white and soft up to two years, after which time it gradually ossifies, and at 3 years one-half to two-thirds its length is bone. See Fig. 25.

No. 3 and "stripper" ribs are also made into "rolls". A "regular roll" consists of the lean part of the rib, stripped of the backbone, shoulder blade, fat and outer layer of meat. They weigh 4 to 8 pounds, and are used for small steaks. "Spencer rolls" are of better quality and heavier averages than regulars, and the fat and outer layer of lean are left on except that portion above the shoulder blade. Spencers average from 6 to 12 pounds, and are used for roasts and steaks. Both styles of roll are used chiefly for restaurant and small hotel trade and are sold frozen to a considerable extent.

"Pieces" consist of the rib and navel in one cut. Fore quarters from which only the ribs have been cut are called "triangles", "rattles", "slugs", "L's" or "knockouts" (Fig 22). They are graded No. 1, No. 2 and No. 3 in the same manner as straight cuts.

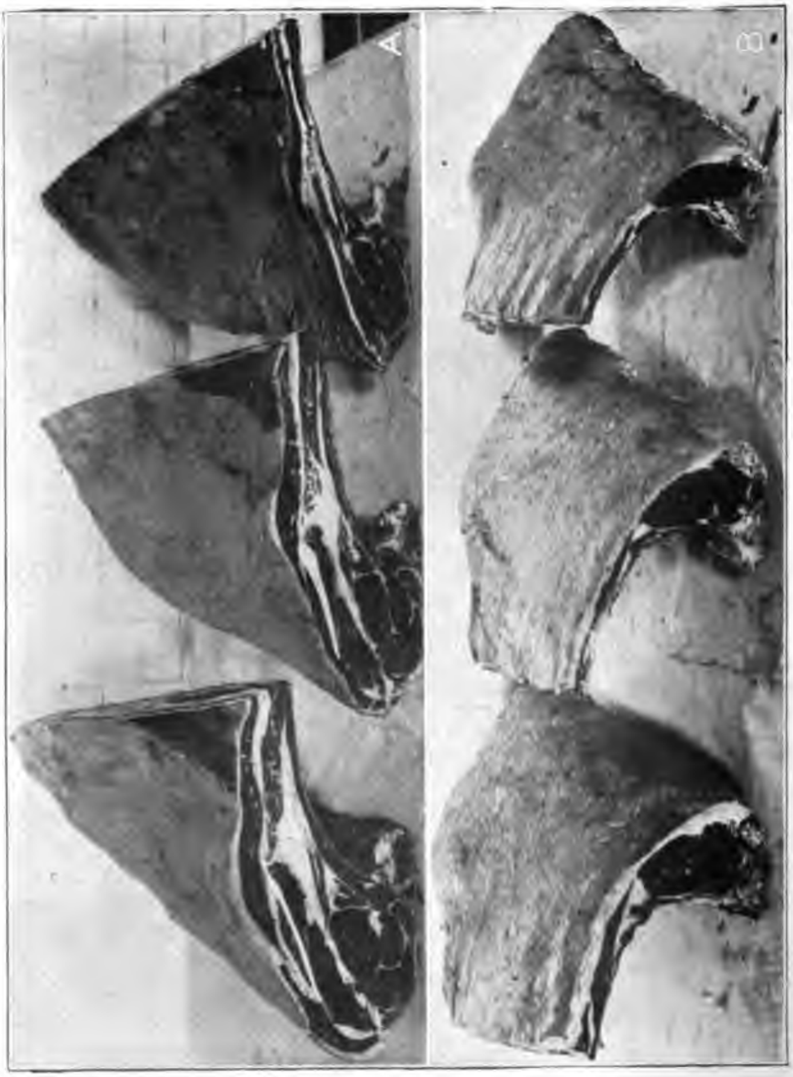

FIG. 25. RIBS, NO. 1, NO. 2 AND NO. 3 GRADES. A, FRONT; B, REAR.

ROUNDS

The cut surface of the full round being identical with the butt end of the corresponding loin, the conditions as to grain, marbling, covering and color at that point determine the grade in each case alike. Rough or lumpy cod fat indicates a steer round, a soft, flabby bag a cow round, and a firm or hard bag a heifer. Also, in steer rounds one end of the aitch-bone is surrounded by the lean flesh of the "inside", while in cows and heifers it is surrounded by fat; and the exposed portion of the "inside" is comparatively narrow or flat in cows but rounded or triangular in steers. The shape of rounds varies exceedingly, as can be seen most readily by comparing the carcasses shown in Figs. 1 to 20. See also Fig. 26. Since the proportion of steaks which can be cut depends upon the shape of the round, the importance of this factor is evident. No. 1 rounds are generally valued at 40 to 60 percent less than the price of loins and ribs of the same grade; while No. 3's are generally quoted only 10 to 30 percent below No. 3 loins and ribs. Rounds sell relatively higher in summer than in winter because they are used principally for cutting small steaks.

Three wholesale cuts for fresh trade are made from rounds, viz., the buttock (quoted as "round, R. & S. off"), rump, and shank. On the average about 60 percent of the full round weight is buttock, 20 percent rump and 20 percent shank. The buttock is wholly suited to cut as round steaks, those nearest the rump being of best quality because containing larger muscles and less waste. This cut is quoted at about 25 percent above the price of straight rounds, the difference being less marked in the higher grades. The rump, when used fresh, is usually sold as a *rump butt,* or *boneless rump* (Fig. 27). This is made by cutting out the aitch-bone (hip-bone) and trimming off square at loin end, leaving a boneless cut (except the "tail-bone") weighing 5 to 7 pounds and worth about the same price but generally less than the full round. It is used mainly for corned beef. The hind shank consists of about equal parts of bone and boiling meat. The latter, as a retail cut, is known as the "heel of the round" or "horseshoe piece". Shank meat is principally used, however, for Hamburger, sausage trimmings, or similar purposes.

The American preference for loin and rib cuts renders it necessary to dispose of a large share of the lower grade rounds otherwise than over the block as fresh cuts. For this purpose they are stripped and made into "beef hams", rump butts and shank sausage meat. The buttocks of cow, bull and stag carcasses are best adapted for making beef hams. At least a partial covering of fat on the round is required for the bulk of this beef, but the cheapest

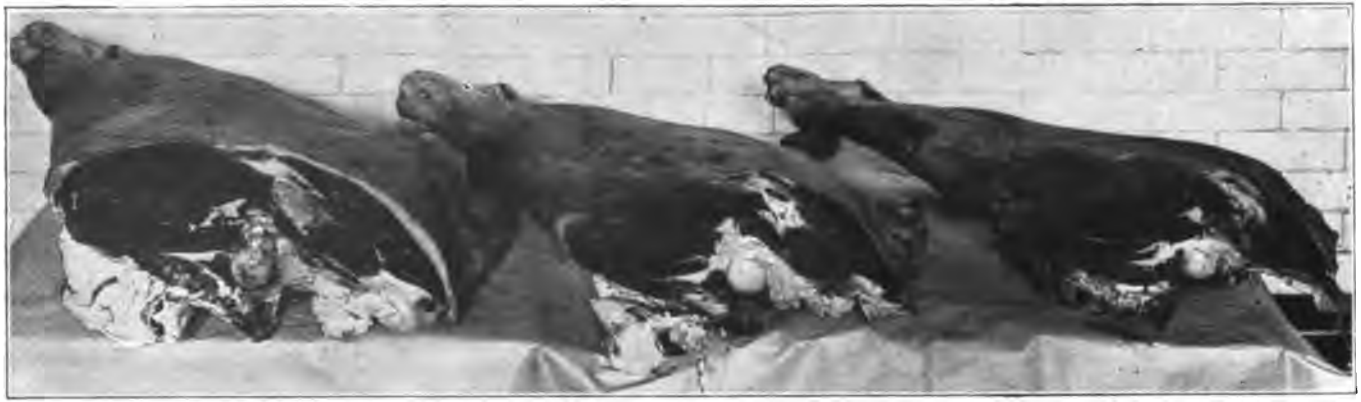

FIG. 26. ROUNDS, NO. 1, NO. 2 AND NO. 3 GRADES.

grades are packed from rounds which are almost entirely free from fat. It is impossible to cure beef satisfactorily that has not reached maturity or nearly so, since it shrinks heavily on account of being more watery and does not "take the salt" as well as beef that is matured. Buttocks intended for curing are cut longer than regular, leaving a smaller rump piece. In stripping a buttock for beef hams, it is divided into three boneless pieces according to the muscular divisions of the round, making an "inside", "outside" and "knuckle". These cuts are known as a *beef set* (Fig. 30). The average proportions by weight of the three "beef hams" are 42 percent, 31 percent, and 27 percent, respectively; but the outside and knuckle are sometimes divided equally. They are frequently stored in freezers, either fresh or in brine, until it is desired to cure them. The rounds of canner sides and others of very light weight and poor quality are used to some extent for canning or sausage purposes. A "Scotch buttock" is a boneless buttock, principally from heavy No. 1 rounds, a few being made from No. 2's. Rumps are not cured to the same extent as buttocks. When barreled they are sold principally as rump butts and mess beef. For description of cured beef products made from the round, see page 210.

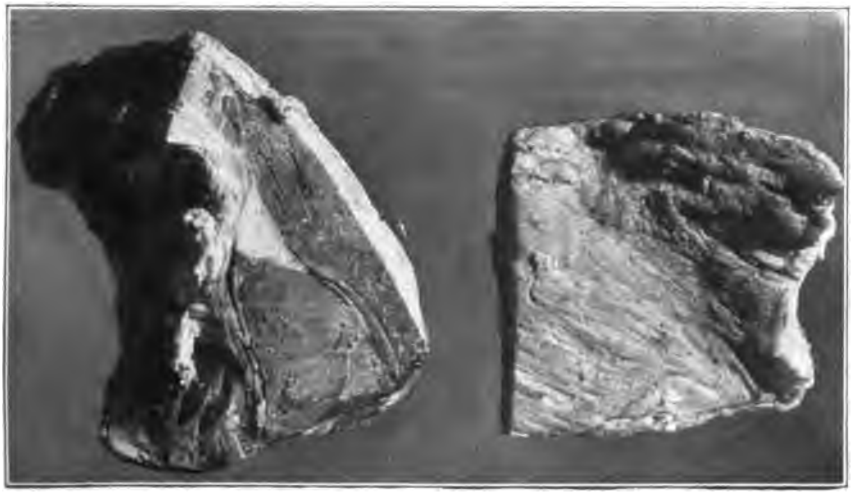

FIG. 27. RUMP BUTTS.

CHUCKS

Thickness, shape and color are the most important points considered in grading chucks; and the covering of fat is of much less consequence than in loins and ribs. The general quality of chucks is indicated by the chine and brisket bones, color and grain of flesh. No. 1 chucks have a complete covering of fat, which is thickest along the rib end of the cut. No. 2's have little and No. 3's no covering (Fig 28). Nearly equal parts of the chuck are retailed as shoulder steaks and boiling pieces, and a roast may be cut from the last two or three ribs of No. 1 chucks. Pot roasts are cut from the lower or shank side, and stews or soup meat from the neck. The proportions of the chuck which are suitable for roasts, steaks and boiling meat vary greatly according to thickness and shape; and in view of the wide difference in market value of those cuts, the importance of compact shape and full thick development of lean meat are apparent. The chine bones and shoulder blade give a clue to the age and maturity of the carcass, as explained in connection with the rib cut.

The style of cutting shown in Fig. 22 is known as the square chuck, and is the style most used in Chicago wholesale markets. Chucks are sometimes cut "knuckle out" by removing the shank with a knife at the second knuckle* instead of sawing off below the joint. The lower grades of chucks are often further divided in order to make the cut more salable. Such cuts are the *shoulder clod* and *boneless chuck.* The shoulder clod (Fig. 30) is a wedge-shaped piece cut from the fleshy part of the chuck just back of the shoulder blade, and extending from the elbow of the shank nearly or quite to the back-bone. It is taken mainly from No. 3 and "stripper" cuts, and to a small extent from No. 1's and 2's. It is a boneless cut weighing six to fifteen pounds, and sells from 10 to 20 percent above chuck quotations. It is used for steaks and roasts, especially in restaurants and small hotels; and is in some cases smoked and sold as a "dried beef clod". Boneless chucks are cut "knuckle out" and have the shoulder blade and ribs removed. They are made only from "stripper", No. 3 and light No. 2 chucks; they weigh slightly less and sell about 10 percent higher than full chucks of the same grade. They are principally used for sausage. Necks and neck trimmings are also quoted as sausage-meat, and are used fresh to some extent for soup, hash and mince-meat.

Scotch clods are also made from boneless chucks. This is an entirely lean cut, consisting of the inner portion underneath the blade bone, and is the best part of the chuck. It is principally frozen and exported to Great Britain.

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*The upper or shoulder joint.

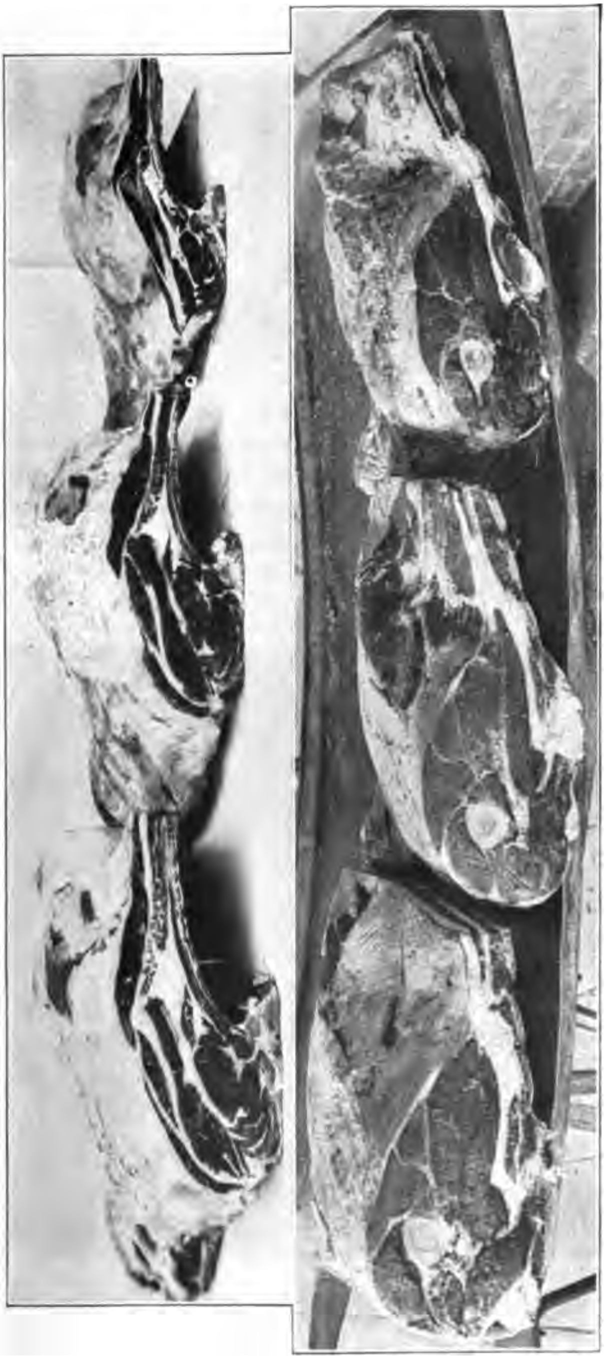

FIG. 28. CHUCKS, NO. 1, NO. 2 AND NO. 3 GRADES. (ABOVE, REAR VIEW. BELOW, SIDE VIEW).

"Kosher" or "New York" chucks consist of the square chuck, shank, brisket and neck, in one piece, (in other words, the fore quarter with rib and navel taken off) cut from Kosher cattle (p. 188). They include about one-third of the carcass weight. Beef sold to Jewish trade is mainly confined to this cut, altho ribs and navels may be so used. Kosher chucks are cut from all grades of cattle that yield other regular cuts for fresh trade, but the greatest proportion are from choice and good sides. They command a price slightly above the average price of the parts which compose them and thus sell at very nearly the price of full rounds of the same grade. About 10 percent of the carcass beef sold locally in Chicago is cut in this fashion and none is shipped owing to restrictions of Kosher regulations. See Fig. 29.

The portion of the carcass left by the removal of the Kosher chuck is called the "hind and piece", and consists of the regular hind quarter, rib and navel piece together. A beef *back* or "back half" consists of a square chuck and rib in one piece. This cut is not extensively used. See Fig. 22.

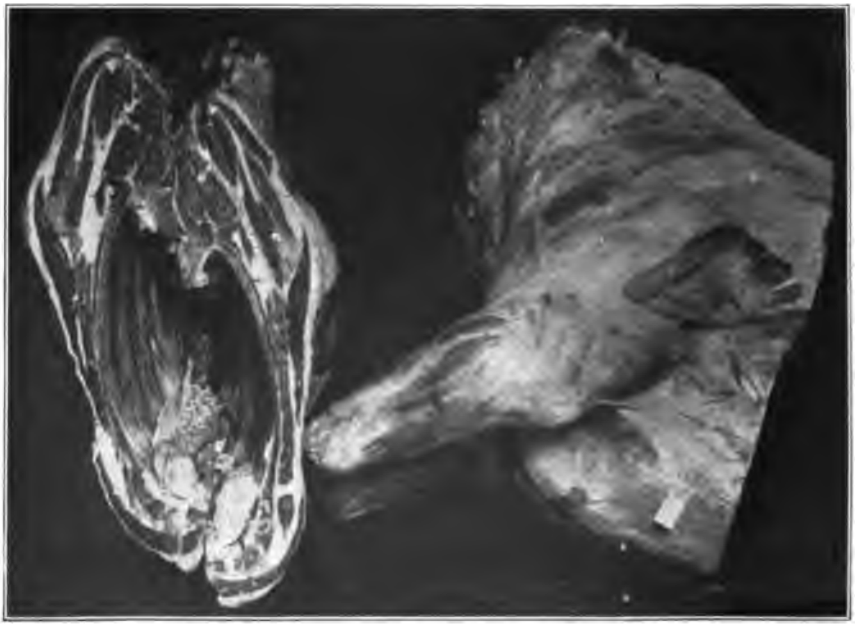

FIG. 29. KOSHER CHUCKS, NO. 1 GRADE.
REAR VIEW. SIDE VIEW.

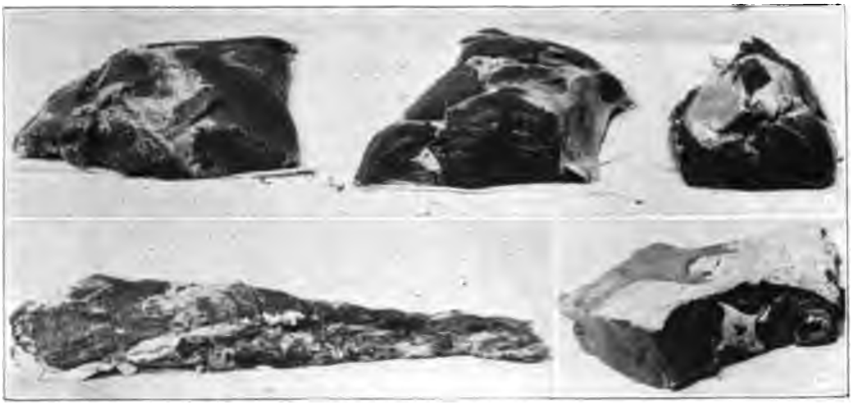

FIG. 30.
A, Beef Hams, (Left, "Inside"; Center, "Outside"; Right, "Knuckle".)
B, Tenderloin. C, Shoulder Clod.

PLATES

The most essential points in grading plates are thickness of the cut, proper proportions of lean and fat, and quality of bone. Color, grain and firmness of flesh are less important factors than in case of the more valuable cuts. No. 1 plates are entirely covered with a thick layer of fat, which is most abundant over the brisket, and have a corresponding depth of flesh. No. 3's, most of which are cow plates, are nearly bare of fat except on the brisket end, and differ from strippers principally in thickness of flesh. (Fig. 31.) The grade of a plate is determined more largely by its weight than is that of a loin or rib. Briskets and navel-ends are wholesale cuts made from plates by cutting them in two between the sixth and seventh ribs, the navel-end containing about three-fifths the weight of the plate. Heavy plates are principally barreled and sold as mess beef of various grades (p. 208) owing to the comparatively small retail demand for boiling, stewing, and corned beef. Scarcely one retail market in ten has a demand for fresh plate beef but some are sold fresh to restaurants and hotels. Corned briskets and navels are sold in most retail markets, the latter usually being boned and sold as "beef rolls". Navels were formerly valued higher than briskets, but the latter have become more generally used during recent years and now command a price one-third higher than navels. Strippers and No. 3 plates are boned out for sausage, canning purposes, and soup meat, and few full plates lighter than 30 pounds are barreled.

FLANKS

As the flank is a boneless cut, its quality and grade depend entirely upon the thickness and quality of the lean and fat. The

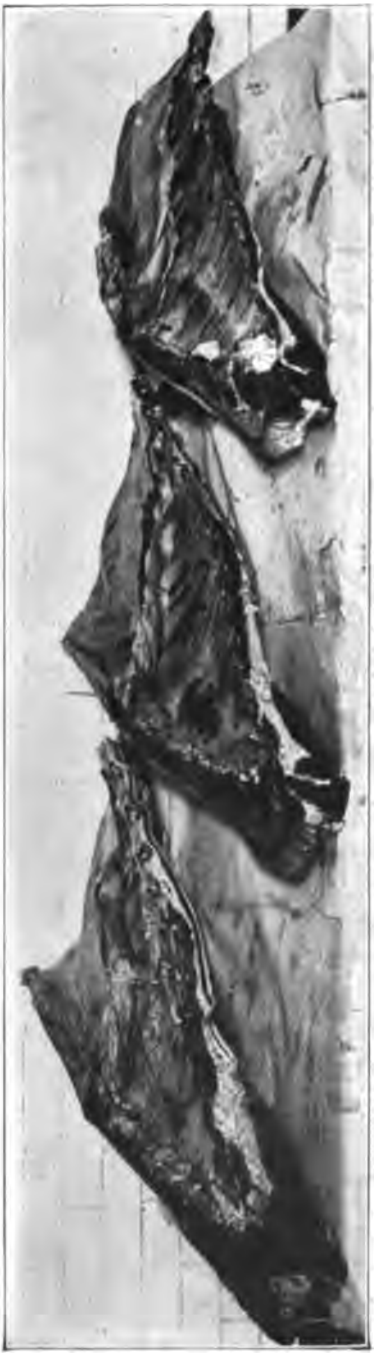

FIG. 31. PLATES, NO. 1, NO. 2 AND NO. 3 GRADES.

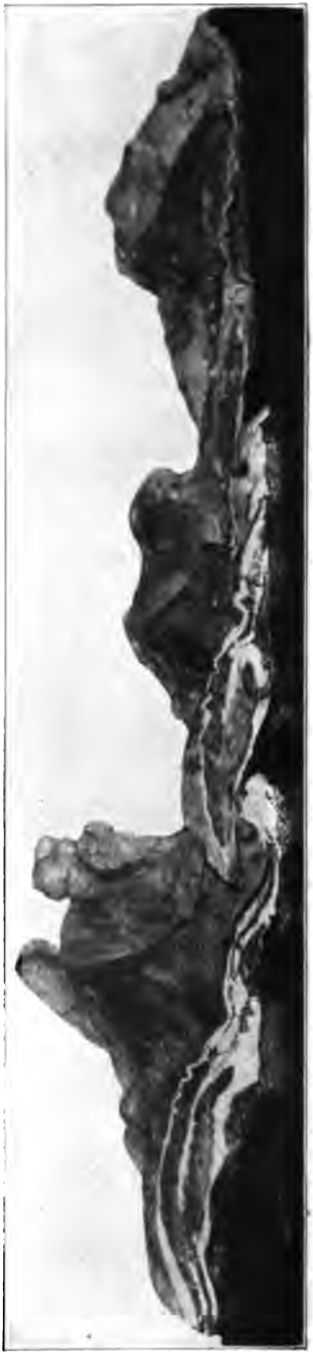

FIG. 32. FLANKS. NO. 1, NO. 2 AND NO. 3 GRADES.

color and grain of flesh are less variable in flanks than in the more valuable cuts, consequently the grades correspond more closely to the weights given on page 193. No. 1 flanks are thick-fleshed and covered with solid, white fat; No. 3's are thin, soft and in many cases very dark-colored and flabby. The shape and thickness of the different grades are shown in Fig 32. No. 1 and No. 2 flanks are to some extent retailed in the form of flank rolls, either fresh or corned, but they are principally barreled as mess beef (p. 209), and the lighter grades made into sausage and canned corned beef.

While straight flanks are handled but little by retail trade, they contain a cut known as the flank steak, which is used fresh extensively. It forms only about 10 percent of the flank weight but is worth about twice as much per pound as the straight flank. It is "pulled" from medium and heavy flanks and is graded mainly on a weight basis, No. 1's weighting 1¾ to 2½ pounds, No. 2's 1 to 1¾, and No. 3's less than 1 pound. Flanks are quoted both "steak in" and "steak out".

SHANKS

Except when otherwise specified this term refers in the market to fore shanks, or "shins". Hind shanks are described in this bulletin in connection with rounds. Shanks cut from square chucks are regular or "clod off" shanks. Those taken from "knuckle out" chucks include a part of the shoulder clod and are quoted "clod on". The shank carries little or no covering of fat, and the most important points are thickness of lean with light bone. A large percentage of the supply of shanks are not graded but are stripped (boned) in the packing house, the meat being known as "shank meat", and used for sausage.

Those that are sold fresh are taken by retailers, restaurants and hotels for soup-meat and stews, especially in winter, and are generally graded simply as light and heavy, or below and above 10 pounds. They sell about one-third higher than hind shanks. See Fig. 33.

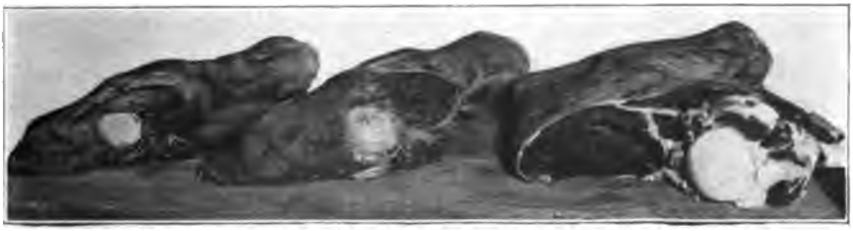

FIG. 33. SHANKS.

No. 3 Grade. No. 2 Grade. No. 1 Grade, Clod On.

SUET

Little kidney suet is sold in the wholesale beef trade beside that which goes with carcass beef. (Fig. 22.) Sides and hind quarters are sold with suet in, and retail meat dealers sell more or less of this fat back to packers or other buyers of "shop fats". It is quoted together with beef cuts, however, and is sold in but one grade, which must be clear white and brittle, and weigh 5 to 10 pounds trimmed. Kidney suet sold at retail is used for cooking purposes as a lard substitute, and for mince-meat especially during the winter season. The bulk of the suet supply is used for the manufacture of butterine, cooking compound, soaps, oleo-oil and stearin.

TRIMMINGS

In making beef cuts, especially boneless cuts and those used for barreled and canned beef, scraps of various size and shape accumulate. Their value depends upon the size and quality of the pieces and the proportion of lean meat they contain. Two grades of trimmings are recognized. The No. 1 grade consists of large pieces that are comparatively free from fat, such as neck, brisket, and chuck trimmings and hanging tenderloins. No. 2 trimmings include rib, loin, tenderloin, flank and navel trimmings, being small scraps with a larger proportion of fat than No. 1's. Both grades are used principally for sausage and canned meats. They are packed in 100-pound boxes or in slack barrels and sold both fresh and frozen; they are also partially cured in tierces with salt, saltpetre and sugar and sold as "curene" trimmings. The supply of trimmings is largest during the fall cattle-cutting season.

CURED BEEF PRODUCTS

As previously stated, about one-fourth of the wholesale beef supply is marketed in a cured form. The plates, flanks and rumps of all grades of cattle are at times used in this way and in the lower grades of beef the round and chuck are quite commonly cut up and cured before marketing. The less salable cuts and grades of beef are held in storage for longer periods and are shipped greater distances than the higher grades, and various cured products are the most economical and convenient forms in which to store and ship such meats. Beef is packed as *Barreled, Smoked* and *Canned* Beef, and is also a constituent of various kinds of sausage.

BARRELED BEEF

Barreled or corned beef is packed in brine and is quoted both in 200-pound (net) barrels, 300-pound tierces and in half- and quarter-barrels. It may be cured in the barrel or cured in vats before packing. The standard barreled beef products are described below. For description of the cuts from which the various grades are made see pages 200 to 207.

Extra India Mess Beef is made from heavy fat No. 1 plates weighing 65 to 80 pounds, cut into pieces of about 8 pounds average and packed in tierces or barrels. It is the highest grade of barreled beef and is sold largely thru British markets for army and navy use. Fulton Market Beef is of the same quality as Extra India but from 60 to 70 pound plates, and is usually put up in half barrels or tubs for domestic trade. These and the two following grades of plate beef are usually packed with the lower side of the brisket piece removed.

Extra Plate (Extra Family) Beef is cut from moderately fat No. 1 plates, (50 to 60 pounds), and packed like Extra India. It is exported principally to various countries in northern Europe.

Regular Plate or Family Beef consists of No. 2 plates (40 to 50 pounds), with good proportions of fat and lean, cut into pieces of 6 to 8 pounds and packed the same as Extra India. It is also sold largely in northern European countries.

Packet Beef is made from 30 to 40 pound plates (heavy No. 3's and light No. 2's) cut the same as other grades of plate beef. It is used thruout Europe, the West Indies, Central and South America.

Common Plate Beef is made from No. 3 plates, 20 to 30 pounds average, cut and packed as explained above. It is the lowest grade of barreled plate beef. This grade, also Prime Mess and Extra Mess Beef, is sold to the same trade as Packet Beef.

Rolled Boneless Beef (Rolled Beef or Rollettes) consists of plates with a portion of the brisket cut off, the remainder of plate being boned, rolled and wound with twine. It is made from No. 2 and No. 3 plates of 25 to 40 pounds average. The rolls weigh 8 to 12 pounds and are cured in mild brine.

Prime Mess Beef consists of about 100 pounds of plates and 100 pounds of chucks, rumps, and flanks per barrel cut into pieces of 6 to 9 pounds. The proportions of the cuts named are varied according to demands and may contain 100 pounds of chucks with the remainder plates, flanks and rumps, or as otherwise specified. This grade is made from heavy No. 3 and light No. 2 cuts.

Extra Mess Beef contains the same assortment of cuts as Prime Mess but is made only from No. 3 cuts.

Rump Butt Beef is cut from rumps off the medium and lower grades of rounds, and is boneless except a small piece of tail-bone. The pieces average 4 to 6 pounds each. It is sold largely in lumbering districts and to the fisheries trade.

Mess Chuck Beef is made from chucks of the medium and lower grades cut into square pieces of approximately 8 pounds. It is used by the same class of trade as Rump Butt Beef.

Beef Hams (see p. 199) are barreled in sweet pickle, both in sets and separately as insides, outsides and knuckles. They are, however, sold in the barreled form only to a small extent, being principally smoked. They are graded according to quality and weight.

Scotch Buttocks (see p. 201) are barreled in a mild plain pickle and shipped to Glasgow especially during the summer season. They are usually made in only one grade from No. 1 rounds.

SMOKED BEEF

Smoked or dried beef is almost entirely limited to beef hams, which, after curing in sweet pickle, are dried and smoked. The method of cutting is described on page 199. Like barreled beef hams, the insides, outsides, and knuckles are sold either separately or in sets, the insides being valued highest, knuckles slightly lower, tho sometimes the same as insides, and outsides lowest. The pieces weigh 5 to 12 pounds, knuckles being lightest and insides heaviest. The heavier grades of each cut are most in demand. Drief beef hams are sold as chipped beef by retail butchers and grocers; much dried beef is also put up in sliced form, sealed in glass jars or tins of from 1 to 5 pounds. The consumption of dried beef is greatest during the summer months.

Shoulder clods (p. 202) are sometimes smoked and known as "dried beef clods". Briskets of choice cattle are also smoked in some cases and sold as "Smoked Brisket Beef", principally to Kosher (Jewish) trade.

CANNED BEEF

This term applies to beef sealed in tins or glass jars. With the exception of a few products the meats are first given a mild cure, and with the exception of dried beef they are partially cooked (parboiled) immediately before sealing. The air is removed from the can or jar by steam pressure or pneumatic suction, and the contents sterilized under steam pressure after the can is sealed. All lean parts of the carcass and especially of the fore quarter are suitable for canned beef. Parts of the rounds and chucks of canner cattle, and of the plates of cutters and dressed beef sides, have sufficient quality and thickness to can in large pieces and sell as roast, boiled or corned beef. The remaining cuts of canner cattle, and trimmings from beef cuts of all grades, are canned in a sliced, chopped or ground form such as chipped dried beef, beef loaf and corned-beef hash, or made into some variety of sausage. Canned beef is principally retailed by the domestic grocery trade but large quantities are exported for the same purpose and to supply army, navy and other contracts. The standard sizes are 1 and 2 pound cans, in cases of one or two dozen, but other sizes up to 14 pound cans are also used.

VEAL

Calf carcasses weighing less than 300 pounds with comparatively light-colored, fine-grained flesh are classed as veal. The veal trade is essentially a fresh meat trade, but little being canned or cured owing to the demand for fresh veal and the difficulty of curing it satisfactorily. Considerable veal is stored in freezers in the same manner as beef. The wholesale markets handle veal both in the carcass and in certain cuts of the same, but about 90 percent of the trade consists of carcass veal. Unlike all other meats described in this bulletin, veal is extensively slaughtered in the country and supplied to the Chicago trade thru commission houses. About half of the local Chicago wholesale trade consists of country-dressed calves, altho statistics show a steady increase in the relative number slaughtered by the leading packers.

CARCASS VEAL

In dressing calves, they are split only thru the hench-bone and breast-bone, as shown in the illustrations. The skin is left on in order to preserve the color and moisture of the flesh, which dries out and turns dark much more rapidly than beef when exposed to the air. Calves sold to local dealers are often skinned at the wholesale markets immediately before delivery. Skinned calves that are sold as carcass veal are usually either split thru the backbone, making two equal sides, or divided into saddles and racks, for convenience in handling. Carcass veal quotations are based on gross weight except where skinned calves are specified.

Grading Veal

The grade and value of a calf carcass depend upon its *form, quality, finish* and *weight.*

The *form* or shape required is a broad, compact body with full thick development thruout and especially in the ribs, loin and legs since those are the most valuable parts. Long shanks and necks, heavy breasts and sharp backs are the most common faults of form. Buyers usually examine the back, flank and brisket by feeling to determine the thickness of flesh.

Quality is indicated by the color and grain of flesh, softness and color of the bones, and general appearance of carcass. The flesh should be light pink, as nearly white as possible, containing an abundance of "baby fat" and free from spots. It should be firm rather than soft and flabby, and should be smooth and velvety in appearance. Dark-colored or coarse-grained flesh is an indication of too much age, insufficient nourishment, or too much coarse feed; while milk-fed calves are easily distinguished from others by their bright fine-grained flesh and clear, white fat. The bones should be small as indicated especially by the shanks; and the back-bone and breast-bone should be soft and red. The ribs of choice young calves are also red with blood. White, soft, cartilages or "buttons" on the chine-bones and brisket also indicate desirable quality. Properly finished native calves four to six weeks old produce the most salable veal, but many choice natives are eight weeks old; Westerns are best at eight or ten weeks; and calves under three weeks old are subject to condemnation. The "toes" (dew-claws) harden at two or three weeks of age. A thick soft coat of hair and bushy tail are characteristic of choice calves, as against short hair lying close to the skin and a small "whiplash" tail such as are often found on western calves. Sex is of small importance in carcass veal. Buyers prefer heifers somewhat and object to the filling of orders entirely with steer or bull calves, but usually buy without reference to this point.

Finish refers to the fatness of the carcass, also to the quality of flesh so far as it depends upon the degree of fatness. It is judged from the amount of fat found on the kidneys, in the crotch and on the flank and breast. On skinned calves the "fell", (a thin membrane which covers the carcass) appears white and soft on well finished calves, while on those lacking finish it is dry and dark-colored. No marbling of fat is found in veal as in beef. The outside fat consists only of the "fell" and of more or less "baby fat" at the flanks, brisket and rump.

Weight is important in its influence on the size of retail cuts and in its relation to the age and quality of the carcass. Average weights of the veal supply vary greatly with the season, being lightest in April and May with the advent of the new calf crop and gradually becoming heavier until the next annual veal season. This variation affects the grading of the higher grades more than the lower ones owing to the greater importance of age and quality in those grades. The weights found in the different grades are given below, and it will be observed that the rating is chiefly on the basis of weight in the lower grades. Dressed calves weighing less than 50 pounds are liable to and usually should be condemned. Some country calves as light as 35 pounds are received, but few below 50 pounds are passed by the food inspectors.

The grades of carcass veal as determined by the above factors, the limits of weight generally found in each grade, and the weights which include the bulk of each are as follows:

GRADES.	EXTREME WEIGHTS	WEIGHT OF BULK
Choice	80 to 120 lb.	90 to 100 lb.
Good	70 to 130 lb.	75 to 95 lb.
Medium	60 to 160 lb.	65 to 80 lb.
Light or Common	40 to 75 lb.	50 to 65 lb.
Heavy	150 to 300 lb.	160 to 200 lb.

CHOICE CALVES

Choice or No. 1 calves, besides weighing within the limits given above, must have the form, quality and finish described in the paragraphs on grading veal. They may be from four to eight weeks old, depending upon weight and finish. See Fig. 34.

GOOD CALVES

Good veal consists of calves which fall short of the most select grade by reason of a deficiency or excess of weight and age; or, if within the requirements in those particulars, lack of finish, quality or form. Insufficient weight and finish are the most common defects of good veals as compared with the choice grade. See Fig. 34.

MEDIUM CALVES

Calves are more often too light than too heavy to grade *good* or *choice,* and the finish of small calves is usually in keeping with their weight. Accordingly, medium veal (also called *fair*) generally runs below 80 pounds. Scarcely any dressed calves over 160 pounds are sold for Chicago city trade, the heavier ones being sent to outside markets. The kidney fat is usually less abundant than in good calves and the form not so smooth nor compact. Many in this grade are narrow in the back, loin and ribs, light in the flank and sharp in the chine. See Fig. 35.

LIGHT CALVES

Except in unusual cases, veal carcasses weighing less than 65 pounds are graded as *common* or *culls* because of the small demand for veal of such light weights. The restricted demand is due to the lack of finish found in such carcasses and their soft, undeveloped flesh. Kidney fat is absent or nearly so. Many cull calves are barely old enough to pass inspection. The lighest culls (35 or 40 pounds) are known as "bob veal" and are usually condemned. See Fig. 35.

HEAVY CALVES

Heavy veal calves vary more in quality, finish and weight than light young calves, and this grade includes both smooth, thick

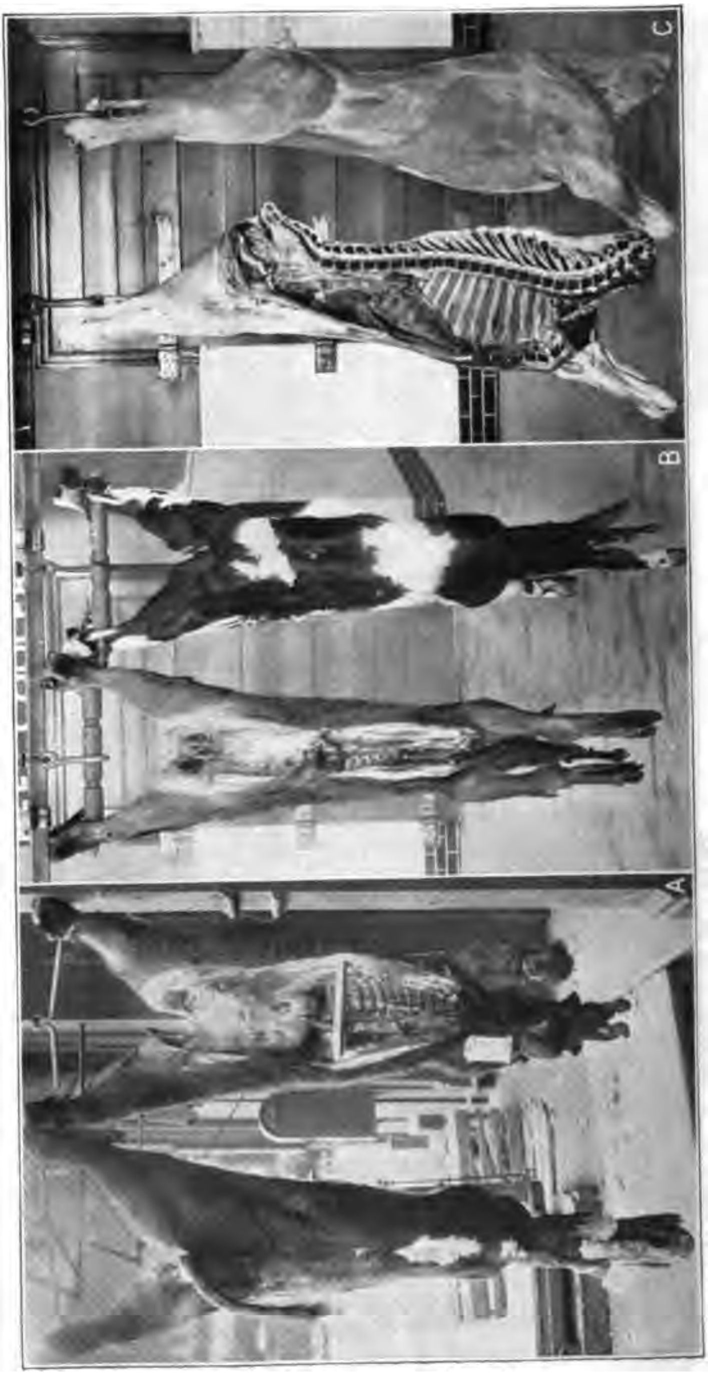

FIG. 34. A CHOICE CALVES. B, C, GOOD CALVES.

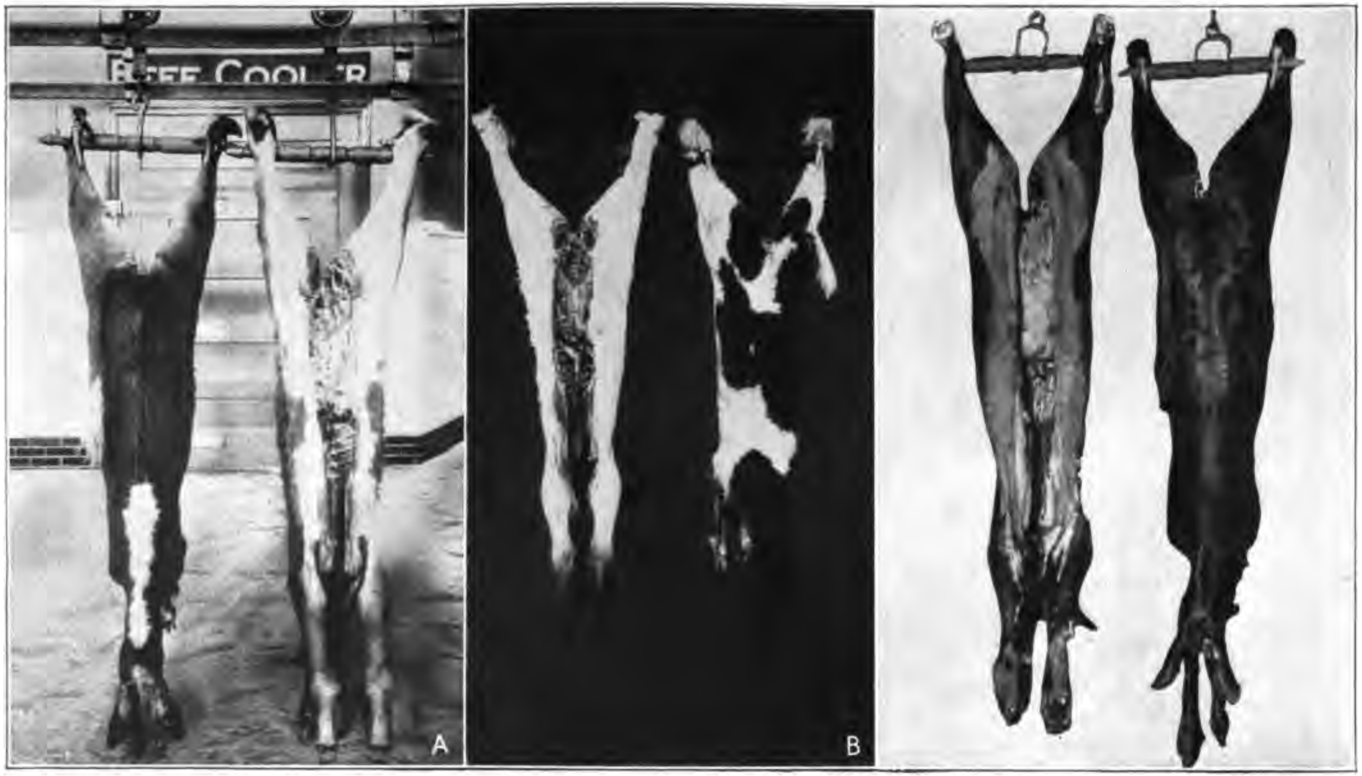

FIG. 35. A, MEDIUM CALVES. B. LIGHT CALVES. C. HEAVY CALVES.

calves of 150 to 300 pounds weight, and the coarse, "bony" sort of the same weights. As a class they sell lower than light calves but in some markets and especially in small cities heavy, well fattened veals sell as high as light and medium grades. Neither heavy nor light calves are valued higher than the medium grade under ordinary conditions. The heavy weights are quoted relatively higher during spring and early summer, when light calves are most plentiful, than at other seasons. It is customary to skin and split the heaviest calves shipped from wholesale houses. See Fig. 35.

"Native" and "Western" Veal

Among dressed calves of the various grades are found those which have apparently been fattened on milk under shelter with little exercise, and shipped but a short distance, if any, before slaughtering; and another class of calves which have had little milk, much exercise, and shrinkage incident to exposure or too long shipment on foot. The former are called *"Natives"*. They have, as a rule, long, soft hair with bushy tail and light-colored, fine-grained flesh, indicating indoor feeding and an abundance of milk. They consist largely of young calves of *choice, good* and *light* grades. Over 90 percent of the dressed veal handled at Chicago is *"Native"* veal, about half of which consists of country-dressed calves consigned to commission firms. A large percentage of veal shipments sent east is also made up of *"Natives"*.

"Western" calves have coarse, dark-colored flesh and short, straight hair, which are indications of insufficient nourishment and care. The bones are whiter and less spongy than those of "Natives", indicating more age. They grade principally as *medium, heavy,* and *light.* Many Western calves slaughtered at Missouri river markets and Ft. Worth are received at Chicago. "Westerns" are best adapted to the trade of small cities and towns because of the wider range of weights and quality which is salable in such markets. A large proportion of Western-dressed calves are frozen during the summer and fall, and held for winter trade. They are skinned before freezing. All grades of "Westerns" are frozen, and the weights most used for this purpose are 100 to 175 pounds.

Kosher veal consists of the fore quarters (including 12 ribs) of calves slaughtered and handled according to Jewish regulations similar to those that apply to cattle (p. 188). *Choice, good* and *medium* calves are the grades principally used.

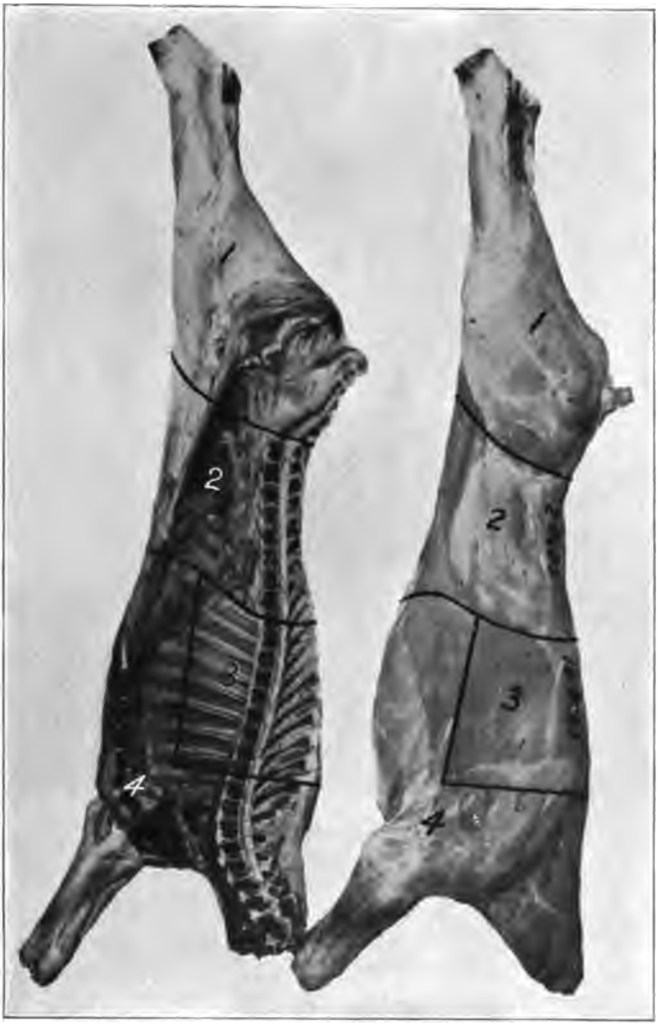

FIG. 36. VEAL CUTS.

1, 2. Saddle (or 2 hind quarters). 1. Leg
2. Loin
3, 4. Rack (or 2 fore quarters). 3. Ribs
4. Stew

VEAL CUTS

Only 10 to 20 percent of the supply of dressed calves are cut up in the wholesale trade, since most retail markets that handle veal have demand for all cuts. A few high-class markets, however, require a larger proportion of choice than of cheap cuts; Kosher

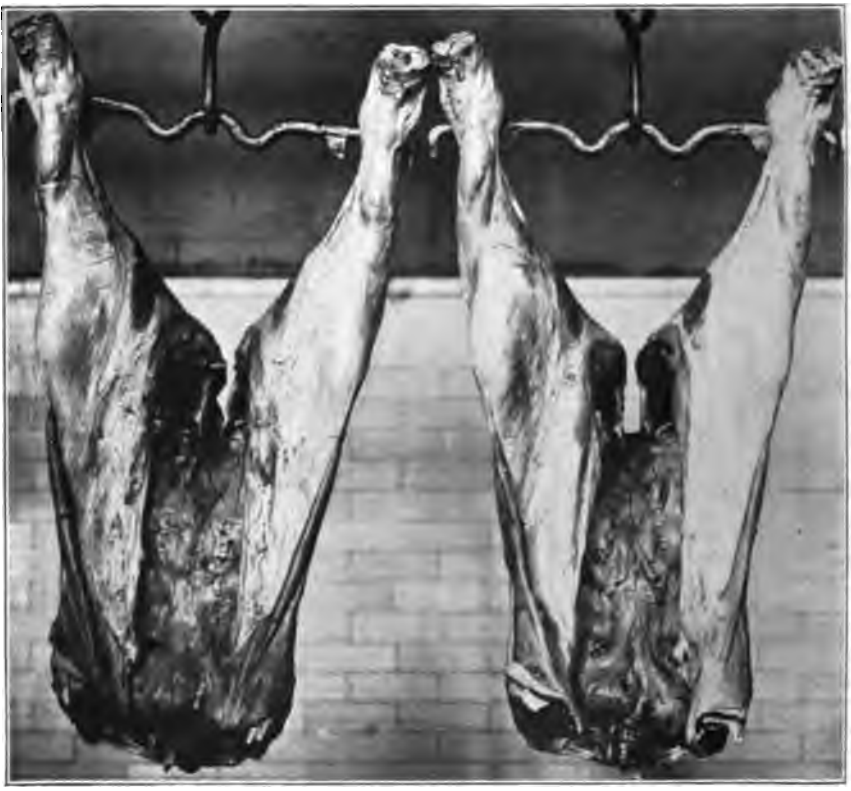

FIG. 37a. VEAL SADDLES.

Choice Good

trade takes only a part of the fore quarters; and a small percent of the supply is cut on account of bruises and other defects. Veal cuts are made from all grades of carcasses but principally from those not better than medium to good in quality and weighing 70 to 120 pounds. The carcass is skinned before cutting.

The cuts most commonly made are the *saddle* and *rack* (Fig. 36). The carcass is "ribbed" between the eleventh and twelfth ribs, the hind quarters together forming the saddle, and the fores, the rack. They are about equal in weight. In some markets the division is made between the tenth and eleventh ribs. Skinned calves are sometimes split into sides in the same manner as a carcass of beef. They are also quoted as separate fore and hind quarters.

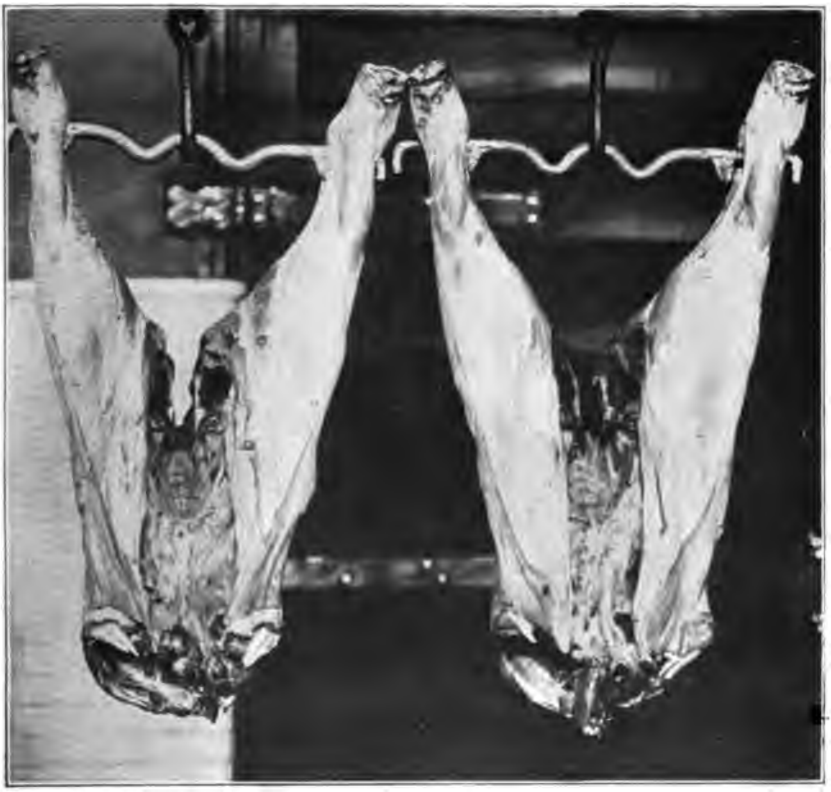

FIG 37b. VEAL SADDLES.

Medium. Common.

SADDLES

The grades of saddless are *choice, good, medium* and *common* (Fig. 37). They weigh 30 to 125 pounds and the lighter weights are usually quoted highest. The most essential points in addition to weight are fullness of loin and leg; firm, light-colored flesh; soft back-bone and hench-bone; and a proper amount of fat, especially evident at the crotch, kidneys and flanks. The value of a saddle depends upon the quality and size of loin chops and leg roasts or cutlets which can be cut from it by the retailer. The two loins are frequently sold in one piece, including about one-sixth of the carcass weight and averaging 10 to 25 pounds. The legs constitute slightly more than one-third the carcass weight and average 20 to 40 pounds per pair.

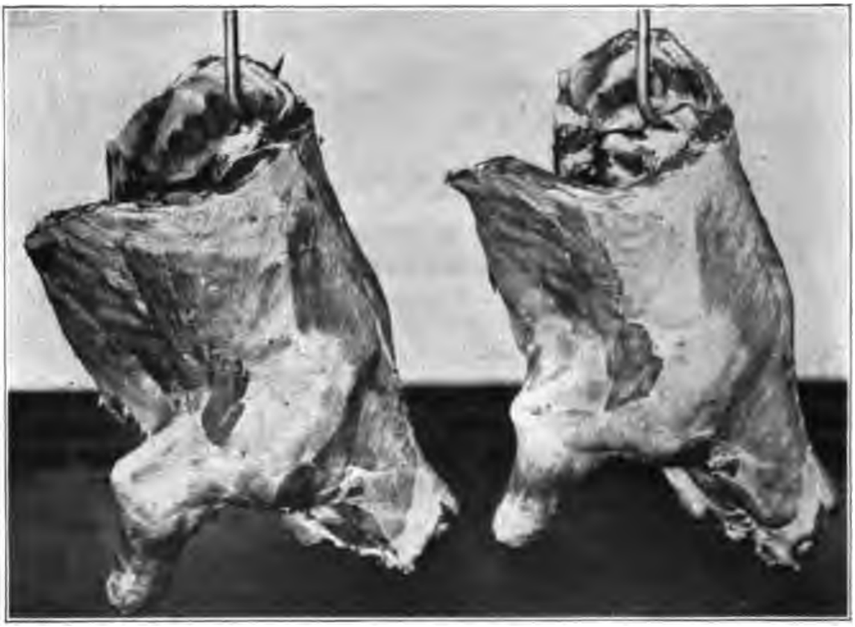

FIG. 38a. VEAL RACKS.

Choice. **Good.**

Hind quarters are graded in the same manner as saddles, and the weights quoted are 15 to 60 pounds.

RACKS

Racks are graded *choice, good, medium* and *common* and are quoted in the same weights as saddles, viz., 30 to 125 pounds (Fig. 38). They are judged largely by the thickness, quality and color of flesh; softness and color of back-bone, brisket and ribs; and shortness of shanks and neck. The part of the rack most valuable to the retailer is the rib cut or hotel rack, which is used for chops. This is sold as a wholesale cut in some markets, weighing 5 to 12 pounds. The remainder of the rack is known as the stew or chuck. The two chucks include about one-third of the carcass weight, and average 10 to 25 pounds each.

Fore quarters are sold separately to a small extent. They are graded on the same basis as racks and weigh the same as hind quarters, viz., 15 to 60 pounds.

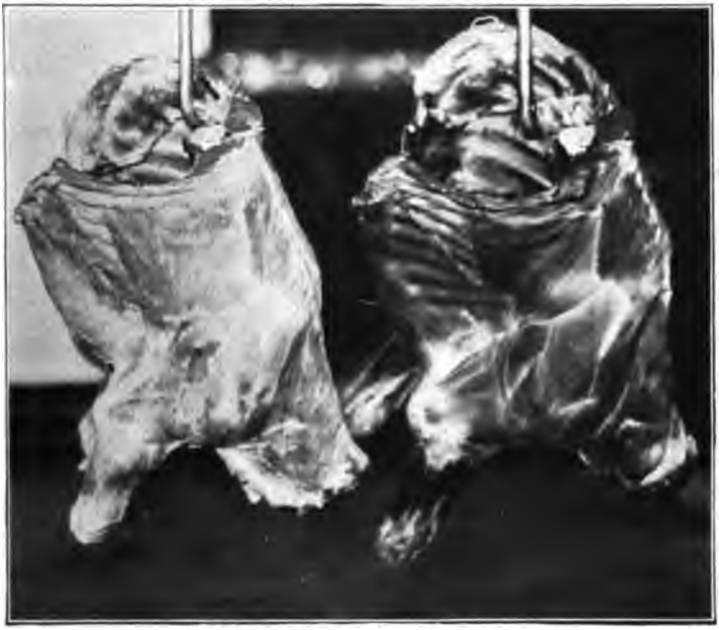

FIG. 38b. VEAL RACKS.

Medium. Common.

A body of veal is the carcass minus the legs. It includes slightly less than two-thirds the weight of carcass. Bodies are graded in the same manner as carcass veal.

MUTTON AND LAMB

Dressed sheep and lambs are handled and classified together in the wholesale trade and may therefore be described and illustrated together most readily. Mutton and lamb are sold almost entirely as fresh or frozen meats, and the bulk of supplies, except those frozen, are disposed of within a week or ten days after slaughter. Chilled and frozen mutton and lamb are handled at the same temperatures as beef. Only a few heavy fat sheep are held in chill rooms for ripening. The freezing of mutton and lamb, however, is carried on to the same relative extent as that of beef. The freezing season extends from September to February. Only a small percentage, and that of the lowest grades, is canned, and practically none is cured.

Because of their high market value, mutton and lamb are used by a wealthier class of consumers on the whole than beef, pork or even veal. Careful and quick slaughtering and good facilities for refrigeration are more essential to the proper handling of this meat than is true of beef or pork. For these reasons the use of mutton and lamb is more largely confined to city markets, and they come into closer competition with poultry, game, etc., than is true of other meats. For the same reasons, together with the fact that lamb is equal or superior to mature mutton in flavor and palatability, the demand for lamb is large in comparison with mutton, and approximately two-thirds to three-fourths of the wholesale supply of mutton and lamb consists of the latter. The wholesale trade in both lamb and mutton has shown a remarkable increase during the past fifteen years, having at least doubled during that period. Improvement in quality of supplies and the development of facilities for slaughter and distribution have rapidly stimulated demand among all classes of consumers.

The proportion of dressed sheep and lambs to cuts of the same sold in the wholesale markets varies widely. In most large cities one-half to three-fourths of the trade is made up of whole carcasses.

CARCASS MUTTON AND LAMB

Various styles of dressing are used for different branches of the trade, and since the market value depends upon the manner of dressing as well as the grade of meat, both are usually specified in mutton and lamb quotations. *Plain or round-dressed* (R.D.) sheep and lambs have the pelt, head and toes removed and foreleg folded at the knee; they are opened only from the cod or bag to the breast, split about half way thru the breast-bone, and a spread-stick placed inside the fore-ribs. (Fig. 40.) This is the style most commonly used in dressing sheep; and the best grades of lambs are usually dressed in the same manner. *Caul-dressed* (C.D.) carcasses have the ribs and flanks turned outward and fastened back with set-sticks, and the caul wrapped about the legs and laid over the inside of carcass (Fig. 46); the object being to improve the appearance, prevent drying out and in some cases (especially in lambs) to furnish the fat necessary for proper cooking. The lowest grades of sheep and all grades of lambs are caul-dressed. The term *pelt on* refers to lambs from which the pelt and head have not been removed. This style is generally confined to light lambs. They are opened the same as round lambs, and in some markets are dressed with back-sets, and caul laid over the belly. Sheep and lambs dressed either plain, round, or "pelt on" are quoted *pluck in* and *pluck out.* The pluck consists of the heart, lungs, liver and windpipe and is either left attached to the carcass or removed, as indicated by these terms. Lambs are generally sold *pluck in* and sheep *pluck out.* Government regulations now require the toes to be removed from all dressed sheep and lambs. Some of the photographs reproduced in this bulletin were made before this rule was passed.

CLASSES AND GRADES OF CARCASS MUTTON AND LAMB

The classes of dressed sheep and lambs are *Wethers, Ewes, Bucks, Yearlings* and *Lambs.* This classification is based on differences in sex and degree of maturity which will be described in connection with each class.

The grades of carcasses in the different classes are designated by the terms *choice, good, medium, common* and *culls* or *canners.* Altho the terms "prime", "fancy", "extra choice", etc., are sometimes used in referring to carcasses of "show quality", they are less commonly used than in the beef trade owing to the wider variation which exists between the grades of beef; and the term *choice* is generally applied to all mutton and lamb above the *good* grade. *Medium* and *fair* denote the same grade, and refer to the average of each class.

Grading Mutton and Lamb

The grade and value of a carcass depend chiefly upon its *form, quality, covering* and *weight.* The method of grading is the same in principle as the grading of beef, which has been fully explained (p. 156). It is only necessary, therefore, to state the specific points to which these terms apply in the grading of dressed sheep and lambs.

Form. Good width in proportion to length together with compactness and smooth even outlines are the essential points of good shape. This implies a thick loin, broad back, well-meated ribs, a full, thick middle from shoulder to leg, plump, thick legs filled well down on the shanks, and smoothly covered shoulders. The most common faults of form are long, slender legs, narrow backs, lack of development over ribs and loin, and too much "barrel" or "belly". Long necks in ewes and heavy "bucky" necks, shoulders and briskets in wethers are objectionable.

Covering. This refers to the fatness of the carcass. It is essential because of its influence on the appearance of the dressed sheep, quality of the meat and shrinkage both in storage and in cooking. The fat should be smooth and even over the entire carcass, but only in the most highly finished sheep are the legs and shanks completely covered. The kidney fat is an important indication of finish in the minds of mutton experts. It should be well-developed but not excessive. A light kidney usually indicates lack of finish, while a very heavy one shows either an overdone condition or an uneven distribution of fat. The cod, udder, rump, flanks and brisket are other points at which the amount of fat is plainly apparent, but it should not be excessive at any of these parts. The lowest grades have practically no outside fat and the amount of covering varies more or less directly with the grades of mutton from common to choice. The covering and kidney-fat should be firm, brittle and white.

Quality. Altho a carcass of high quality must be good in form and covering, it must, in addition, have proper quality of flesh and bone, and good general appearance. The flesh should be firm and fine-grained, without the stringy, coarse appearance of aged or inferior mutton. The color of flesh varies from light pink in lambs to dull red in mature mutton, and is less variable than in beef. The covering and kidney-fat should be clear and white. The bones are an important indication of the maturity of the carcass. In lambs the brisket is soft and red, and the ribs and shank bones are colored by blood-vessels. In mature sheep the bones are white and hard. The break-joint (Fig. 39) which is described in connection with yearlings (p. 231), distinguishes lambs and yearlings from mature sheep. In no branch of the meat trade is general quality so important as in mutton and lamb, owing to the custom of using the carcasses for display purposes in retail markets. It must be so dressed, chilled and handled as to have a bright attractive appearance. In grading caul-dressed carcasses the color and quality of the caul are considered and it should be white and brittle. The quality of "pelt on" lambs is judged partially by the pelt and head, which should show no signs of coarseness. The plucks of lambs dressed "pluck in" must have a bright fresh appearance. This depends largely upon careful slaughter and refrigeration.

Weight. This is a more important factor in grading mutton than in grading beef because differences in form, covering and quality are smaller than in beef, and because the weight is often a strong indication as to whether a carcass is a lamb, yearling or

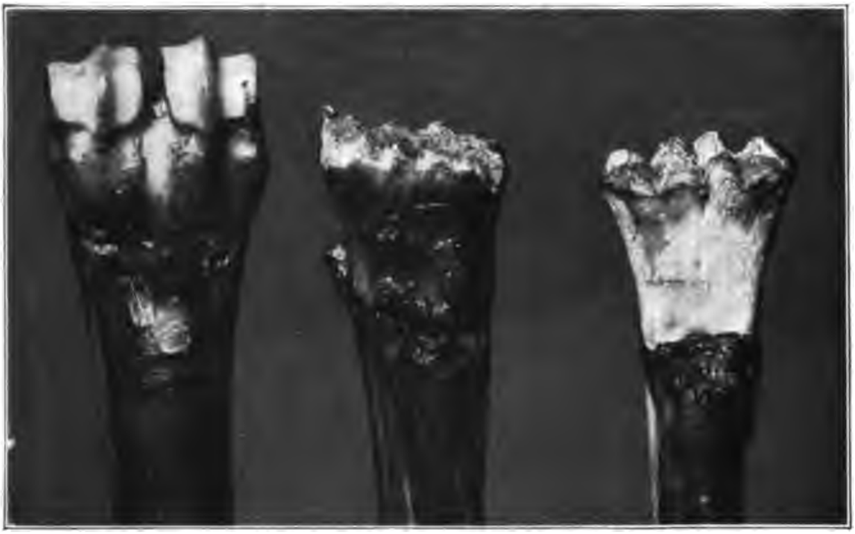

Fig. 39. "Round" and "Break" Joints.

mature sheep. The weights purchased by a retailer depend upon the size of chops and roasts which his customers demand; consequently the most desirable weights in the different classes are confined to rather narrow limits. In this respect the mutton and lamb trade is similar to veal. Weight is of more importance in lambs and yearlings than in wethers and ewes, and in the higher rather than the lower grades of each class. Its importance also varies at different seasons and with varying conditions of supply and demand.

WETHERS

Wether carcasses are distinguished from ewes by the cod-fat, from bucks by their smaller necks and shoulders and finer quality, and from yearlings and wether lambs by "round" joints on the fore-legs (Fig. 39). In general they are superior to ewes in compactness of form, shortness of neck and thickness of flesh. Few high grade wethers are seen in the wholesale meat markets and the supply consists largely of Westerns. They are shipped principally to smaller markets and are occasionally exported, tho the export trade has largely decreased. The grades of this class are *choice, good, medium* and *common:* extreme weights of the regular supply are 40 and 120 pounds.

Choice wethers fulfil all the conditions specified in the paragraph on grading mutton. Even covering and quality are especially important; wasty, plain or staggy wethers are discriminated against. Weights in this grade run from 50 to 100 pounds, with a few up to 120 pounds; the handy weights are 50 to 65 pounds and bulk of supplies weigh 50 to 70 pounds. There is a limited but regular domestic demand for this mutton in large city hotels and restaurants and in the dining-car and steamboat trade. See Fig. 40.

Good wethers differ from those of choice grade chiefly in covering and general quality, the majority of this grade being slightly lacking in development of flesh and fat. The covering, however, must be sufficient to suit the consumer of heavy chops and the quality of flesh must be similar to that of choice wethers, since both grades are used largely by the same class of trade. A small proportion of wethers in this grade are too fat to grade choice. The weight seldom exceeds 100 pounds; minimum and average weights are about the same as of choice wethers. See Fig. 40.

Medium wethers are the average dressed sheep of this class and are plainly deficient in shape, covering and quality. However, they are not greatly inferior in either of these particulars, and may be good or choice in one or more of the points mentioned, especially in form or quality. Most medium wethers are partially covered with fat over the back, loin and ribs, but lack covering on the legs and shoulders. On the other hand, extremely fat, "gobby" wethers, especially those of plain quality and heavy weight, are sold at the price of medium sheep. This grade also includes a small proportion of wethers that are somewhat staggy or bucky. Extreme weights found in this grade are 40 and 90 pounds; the bulk weigh 45 to 60 pounds. See Fig. 40.

Common wethers are the lowest standard grade of wethers. Generally they have a small amount of covering over the back and loin but none on the legs; the poorest specimens of the grade, however, have no outside covering and but little fat on the kidneys. They are of very plain form and quality being thinly covered with dry, dark colored flesh, and flinty in bone. To some extent they are caul-dressed, especially the most undesirable sheep of the grade, and cauls from high grade sheep are frequently used for this purpose. They weigh 30 to 80 pounds with the bulk from 40 to 60 pounds. Few of this grade are shipped and the bulk are taken by retailers who supply a cheap trade. See Fig. 40.

A few dressed wethers of such inferior quality as to be unsuitable for block use are found in the wholesale trade, but owing

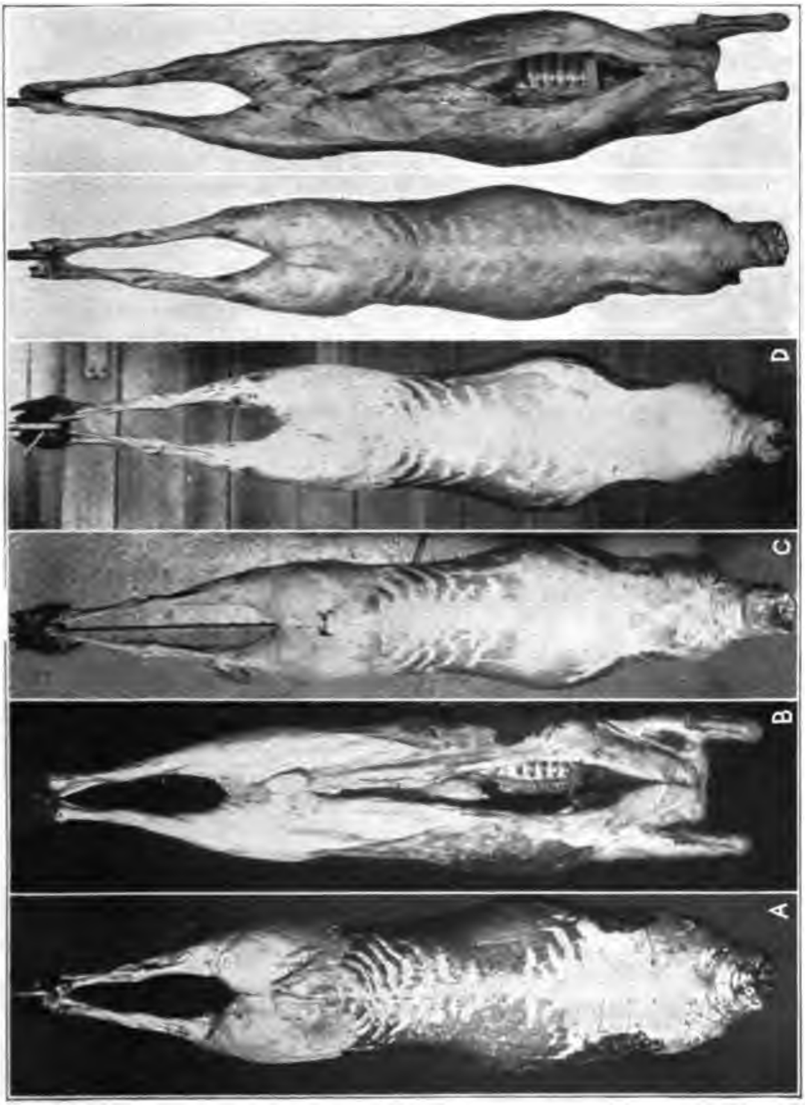

FIG. 40. WETHERS.

Choice. Good. Medium. Common.

to the small and irregular supply they can not be considered a standard grade. The description of canner ewes and their use (p. 230) is applicable to such wethers.

EWES

The "bag" (udder) and a comparatively large "bung" (pelvic cavity) are characteristic of this class of carcass mutton. Ewe carcasses are also distinguished from wethers as a rule by their more angular forms, longer necks, smaller bones and less abundant flesh especially over the loin, back and ribs. In general quality and market value they compare with wethers to practially the same degree that cow and heifer beef compares with steers. Like wethers, they have "round" leg-joints. They are usually more numerous in the markets than wethers, and about two-thirds of the supply of fat, heavy mutton consists of ewes. At the same time, a larger proportion of dressed ewes is found in the lower

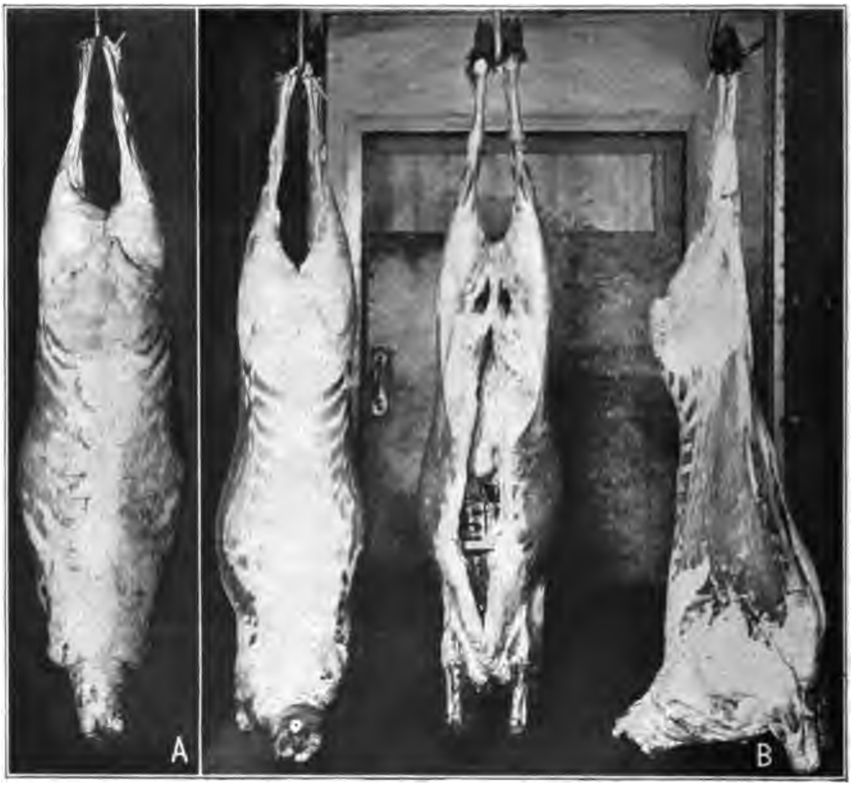

FIG. 41. EWES.

Choice Good (3).

grades than is true of wethers, owing mainly to uneven covering and deficient quality. Light-weight dressed ewes usually classify as "sheep" instead of yearlings because their shanks do not "break" like yearling wethers of the same age and grade (p. 231). The grades of this class are *choice, good, medium, common* and *culls* or *canners.*

Choice ewes are similar to the corresponding grades of wethers excepting the differences enumerated in the preceding paragraph. As a rule they carry more covering and kidney-fat in proportion to flesh than wethers. Choice light ewes (50 to 60 pounds) are usually in greater demand than heavy carcasses because they are less "wasty" in covering; but a limited number of fat 100 to 120 pound ewes is in constant demand for the "English chop" trade

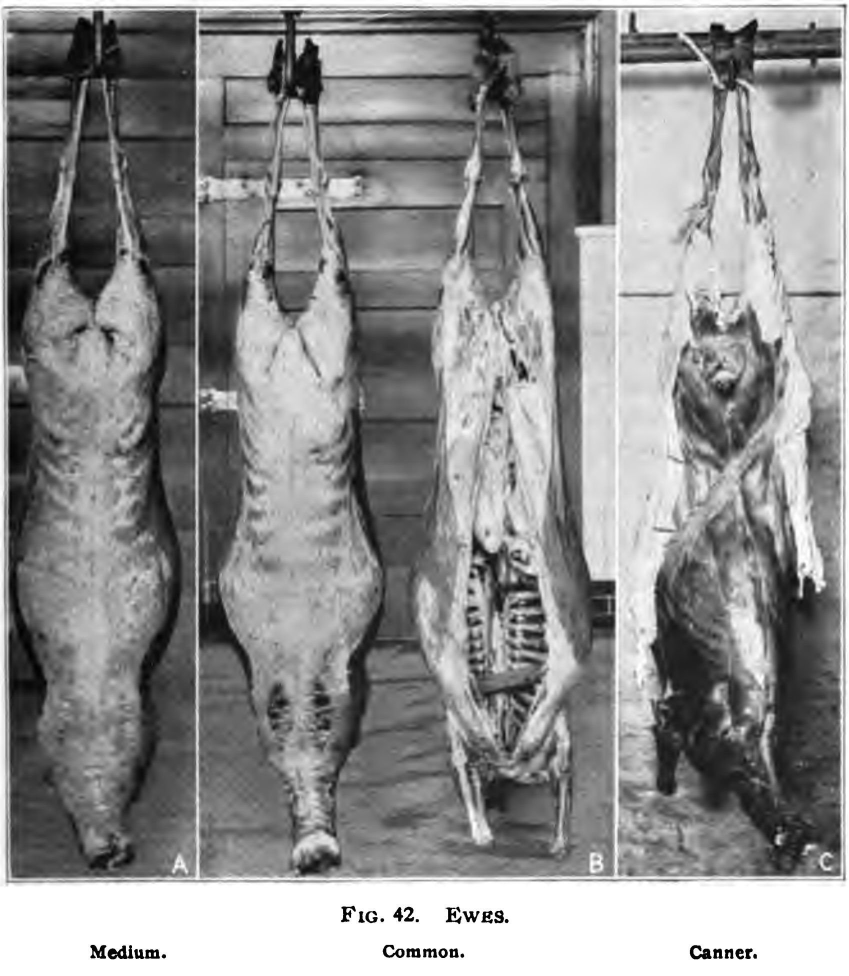

FIG. 42. EWES.

Medium. **Common.** **Canner.**

of large hotels and restaurants, and choice ewe carcasses as heavy as 200 pounds are occasionally seen. See Fig. 41.

Good ewes consist chiefly of 50 to 70 pound sheep slightly wanting in covering, shape or quality; also over-fat carcasses of the heavier weights. The former are sold largely to country or "car-route" trade and the latter to hotel and shipping trade. See. Fig. 41.

Medium ewes are those that are quite deficient in general development, or good in some particulars and decidedly inferior in others, such as quality and finish. They weigh 40 to 100 pounds, but the general run average 45 to 65 pounds. See Fig. 42.

Common ewes have little or no outside fat. They are still darker in flesh and whiter in bone than common wethers and many "shelly" ill-shaped carcasses are found in this grade. They weigh 30 to 60 pounds with a few coarse plain carcasses up to 80 or 90 pounds. See Fig. 42.

Culls or *canners* are the most inferior dressed sheep in the market, and consist principally of old ewes. They are entirely devoid of fat and have not sufficient flesh to be suitable for chops or roasts of even the cheapest grades. They are generally so deficient in flesh that the sides are almost transparent, and are familiarly known to the trade as "jack-o'-lanterns" and "shells". They are most numerous during the fall and early winter. The weights are 25 to 45 pounds and the bulk, 30 to 40 pounds. In most wholesale markets such sheep are sold to city dealers who supply certain laboring classes that are accustomed to use the cheapest mutton for stewing and boiling purposes. Canners are packed by a few firms in the form of "roast mutton", "potted meats", "meat loaf" and certain varieties of sausage. See Fig. 42.

BUCKS

This class makes up only a very small percent of the dressed sheep supply. Bucks can be identified by their thick, heavy necks, shoulders and briskets; large bones, coarse, dark colored flesh and fat, and thick, oily "skin". Market quotations do not recognize them as a class, but they are sold separately from other dressed sheep, excepting light bucks that resemble wethers in covering, form and quality. Many stags and some bucks are difficult to distinguish from wethers; and staggy wethers (p. 226) sell at a discount; consequently the two classes overlap to some extent. Altho the general run of bucks are sold as such in wholesale markets, and are valued 20 to 25 percent lower than wethers of the same grades and weights, they are cut by retailers and jobbers in the same manner as wethers, and the retail cuts are sold quite extensively to the same classes of trade.

The grades of bucks are less distinct than those of other classes of mutton. The terms generally used are *good, medium* and *common.* Good bucks are well covered with fat and have a fairly good quality of flesh. The term "choice" is occasionally applied to selected buck carcasses which are of exceptional quality and finish. Yearling bucks are generally graded *good,* since they resemble wethers more nearly than is true of heavy bucks. Medium and common bucks are graded similarly to the corresponding grades of wethers, considering the general differences noted above. The bulk of supplies in this class weigh 60 to 90 pounds; few exceed 100 pounds, and yearling bucks average 45 to 70 pounds. See Fig. 43.

YEARLINGS

This class may be defined as carcasses that show by their general development and by the "break-joint" that they are not mature sheep, but are too old and generally too heavy to be classed as lambs. The "break-joint" or " lamb-joint" is a temporary cartilage which forms a dentate suture in the head of the shank (shin-bone) immediately above the ankle. (Fig. 39.) In dressing lambs, yearling wethers and some yearling ewes the foot can be broken off at this cartilage, giving the end of the shank a saw-tooth shape; in lambs the broken surface is smooth and moist, and in yearlings it becomes more porous and dry. The shanks of mature sheep will not "break" because the cartilage is knit or ossified and the foot is taken off at the ankle instead, making a "round-joint". Shanks of female or ewe sheep outside the lamb class are, as a rule, too mature to "break". Consequently, yearlings consist chiefly (80 to 90 percent) of wethers; the remainder are ewes and a small proportion of bucks and stags which in this class frequently approach wethers in general quality. It will be seen from the foregoing statements that yearlings are an intermediate class which in certain respects resemble dressed sheep on one hand and lambs on the other. In fact, the terms "yearling lambs" and "yearling sheep" are frequently used by dealers in referring to carcasses of this description.

Yearlings are usually dressed "plain" because of the high average of the class in covering, form and quality as well as their weight, and are sometimes called "plain breakers". As a class they are superior to wethers, ewes and bucks, especially in covering and smoothness of finish. Weight is a factor of special importance in this class because, other conditions being equal, it determines whether the carcass sells on a par with heavy, round-dressed lambs or whether it must compete with wethers. A large proportion of the yearling mutton supply is sold to the same class of trade as

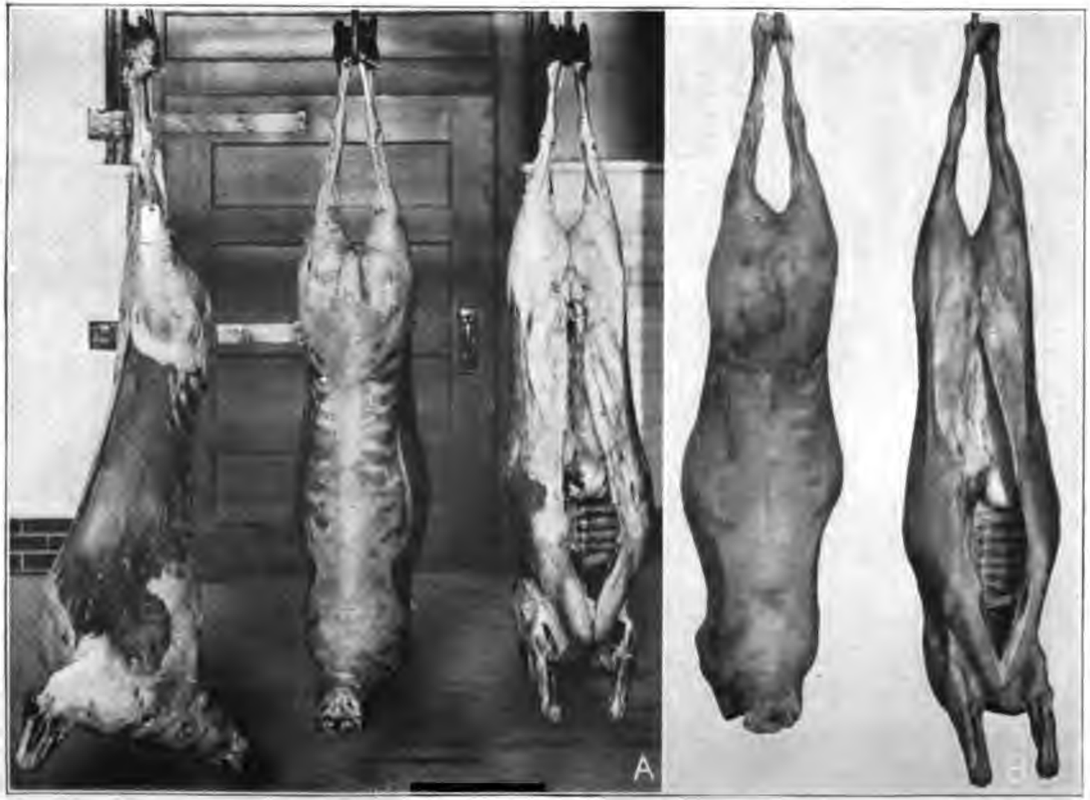

FIG. 43. BUCKS.

Good. Medium.

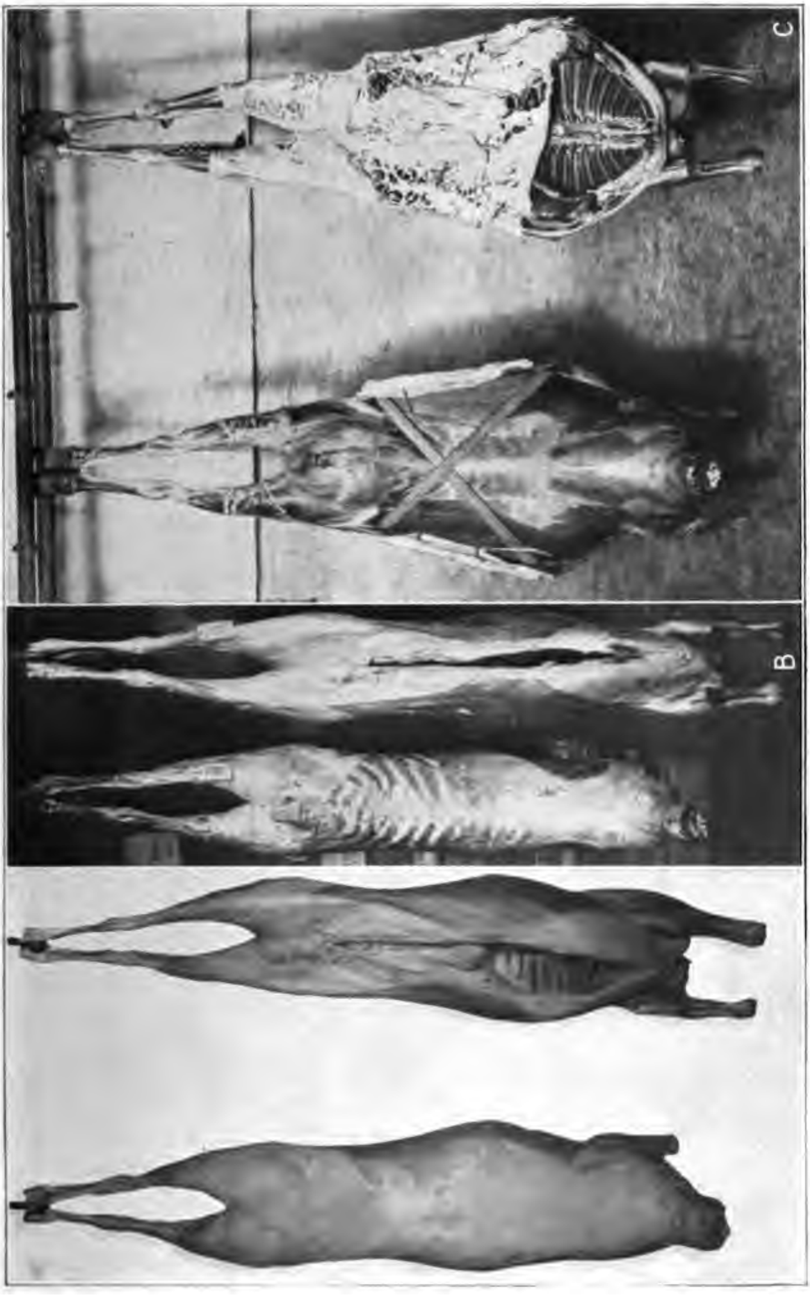

FIG. 44. A, CHOICE YEARLINGS. B, MEDIUM YEARLINGS. C, "CHOPPERS."

heavy lambs. Weights in this class range from 40 to 60 pounds. The grades are *choice, good* and *medium*. Yearlings which fall below medium in form, covering and quality or above the weight mentioned are generally too mature to "break", hence a common grade is not recognized in this class.

Choice yearlings are well covered with fat, with a medium kidney, compact well-rounded form and strictly choice quality. Bright color of flesh and fat and evidence of immaturity in the bones are important, since this grade is substituted for lambs to a considerable extent. They average 40 to 55 pounds. See Fig. 44.

Good yearlings include carcasses that are slightly underfinished or lacking choice quality, and those which have indications of more age than choice yearlings. A small proportion of yearlings are too thickly and unevenly covered with fat and tho otherwise choice, are graded *good*. They weigh 40 to 50 pounds.

Medium yearlings are made up of a still greater variety of carcasses than the good grade. The form and quality are often decidedly plain and the covering deficient, but a few carcasses of heavy weight and good quality sell better as medium yearlings than as good wethers, and are so graded. A few slightly staggy or bucky sheep are also included. The weights in this grade vary from 45 to 50 pounds. See Fig. 44.

"Choppers" or "chop-offs" are a grade of mutton between yearlings and sheep, consisting of light, handy young sheep weighing 40 to 50 pounds, of common to medium quality, similar to yearlings in size and shape, suitable to use as a substitute for yearlings of low grade and dressed to supply a class of retail trade which demands yearlings and lambs but at a moderate price. They are caul-dressed. Wethers and ewes are included in this grade. See Fig. 44.

LAMBS

Carcasses of sheep that are more immature than yearlings are classed as *lambs*. The difference in degree of maturity is indicated principally by lighter color and finer grain of flesh, redder and softer bones, and a break-joint that is smoother and more moist to the touch, combined generally with lighter weight of carcass. Sex is not specified in lamb quotations and only in fancy trade is discrimination made in favor of wether lambs.

About two-thirds to three-fourths of the wholesale mutton and lamb trade consists of lambs and they are sold chiefly to city dealers. The retail market trade of Chicago uses lambs almost to the exclusion of mature mutton. This is due to the demand for

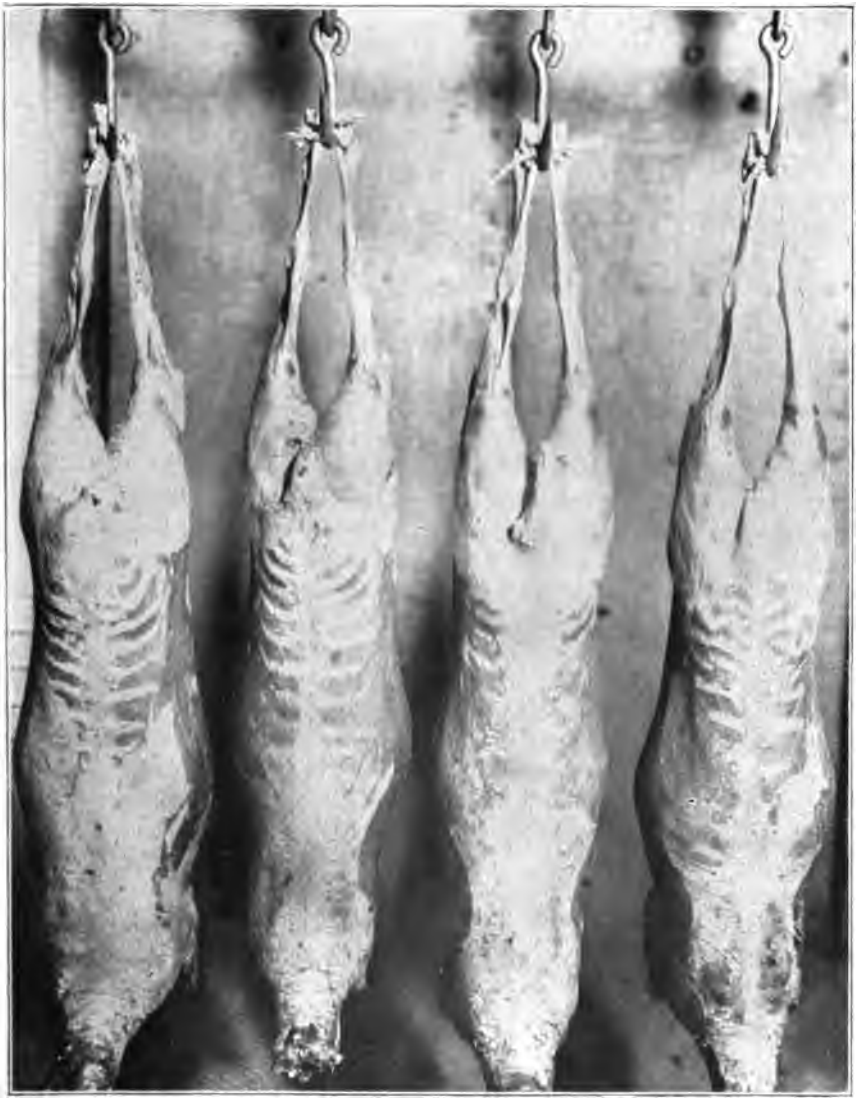

FIG. 45. LAMBS.

Choice. **Good.** **Medium.** **Common.**

small lean chops and legs of lamb, together with the fact that lamb is superior to mutton in tenderness and flavor.

The majority of dressed lambs are known as "spring lambs" from June until December; after August, however, they are frequently quoted simply as *lambs.* Frozen spring lambs are sold regularly, tho in relatively small numbers, during the winter and spring. The terms, "yearling lambs" and "fall lambs" are frequently used during the spring and summer with reference to lambs approaching yearlings in age but similar to spring lambs in size and shape. These terms, however, are used somewhat loosely by the trade and do not denote distinct subclasses.

The grades of lambs are *choice, good, medium, common* and *culls.* The grade is determined more largely by quality and weight and less by form and covering than is the case with carcass mutton. Quality of flesh and bone is especially important for the reasons stated in describing veal. Weight is a matter of much significance in selecting lambs and a decided preference is shown for weights well below those of yearlings because the latter are to some extent sold as heavy lambs. Dressed lambs seldom exceed 50 pounds in weight but no distinct line can be drawn between the two classes either in weight or degree of maturity. The minimum weight of lambs is about 15 pounds and few carcasses weigh less than 20 pounds. Form and covering are of most importance in the *choice* and *good* grades. Plump legs, full, wide backs and loins and thick flanks and breasts are the principal points by which form is judged. In covering, lambs are not as fully developed as yearlings. The back and loin should be well covered but much less fat is found especially on the legs and ribs than in other classes of dressed sheep. *Medium* and *common* lambs are, as a rule, caul-dressed; the *choice* grade is principally round-dressed and *good* lambs either caul or round. All grades of caul and round lambs are quoted both *pluck in* and *pluck out.*

Choice lambs are short, compact and thick, with flesh of the lightest color and finest grain, small bones, and an even covering of white fat. Shape, covering and general appearance of carcass are especially important in choice lambs because they are generally round-dressed. Short, broad, plump legs and full, thick backs and loins contribute most to the desired form since these are the high priced cuts of the carcass. Lambs which are slightly too long and rangy even tho choice in quality and finish are barred from this grade because they resemble yearlings in appearance. Too thick a covering of fat is seldom found in the lamb class. The weights of *choice* lambs are 35 to 50 pounds and the bulk range between 40 and 45 pounds. Chops and legs cut from lambs heavier than 45 pounds are too large to suit the average trade and such lambs are also in closer competition with yearlings, hence they seldom grade higher than *good*. The supply of *choice* lambs is largest during the summer and fall months. See Figs. 45, 46.

Good lambs include a wider range of quality and weight than *choice* lambs and differ from the latter chiefly in the matter of covering. Many carcasses sold as *good* lambs are on the border between lambs and yearlings. The weights of this grade of lambs range from 35 to 50 pounds. The heavier selections weighing 45 to 50 pounds are round-dressed and 35 to 45 pound lambs are principally caul-dressed. The latter are largely used in the eastern shipping trade. See Figs. 45, 46.

Medium lambs are those which are either too rangy in form, coarse and plain in quality or too deficient in covering to bring the price of a good lamb. Many of this grade are too heavy in "barrel" and others are extremely wasty in kidney-fat. The grade also includes some bucky lambs of good quality and covering which are chiefly found in the heavy weights up to 50 pounds. The bulk of the *medium* lambs average 30 to 40 pounds and are caul-dressed. See Figs. 45, 46.

Common lambs are too deficient in flesh and in covering of fat to be suitable for chops or legs of lamb altho they are used on the block in the cheaper classes of trade. They often possess some outside covering but it is confined entirely to the back and loin. This grade also contains a few bucky lambs weighing as high as 45 to 50 pounds but the bulk of the grade weigh 25 to 30 pounds and a few as low as 20 pounds. See Figs. 45, 46.

Cull lambs are of quality similar to that of canner ewes, excepting that the flesh is less dark colored and is usually somewhat more abundant in proportion to the bone. They are entirely devoid of fat and are of the most inferior form and quality. Lambs of this grade are taken by retail markets located in poor city districts and sold for stewing purposes. The weights are 15 to 25 pounds, with the bulk included between 20 to 25 pounds.

"GENUINE" SPRING LAMBS

The term *genuine* is used during April, May and June to differentiate early spring lambs from other lambs which resemble "springers" in quality and weight, such as frozen lambs stored since the previous summer, and light "yearling lambs". It is gradually dropped after the arrival of the regular supply of spring lambs in May and June.

For several weeks after the beginning of the season (about April 1,) "genuines" are dressed "pelt on", the head not being removed, brisket not split and the carcass opened only sufficiently to remove the offal (Fig. 47). The earliest offerings are known as

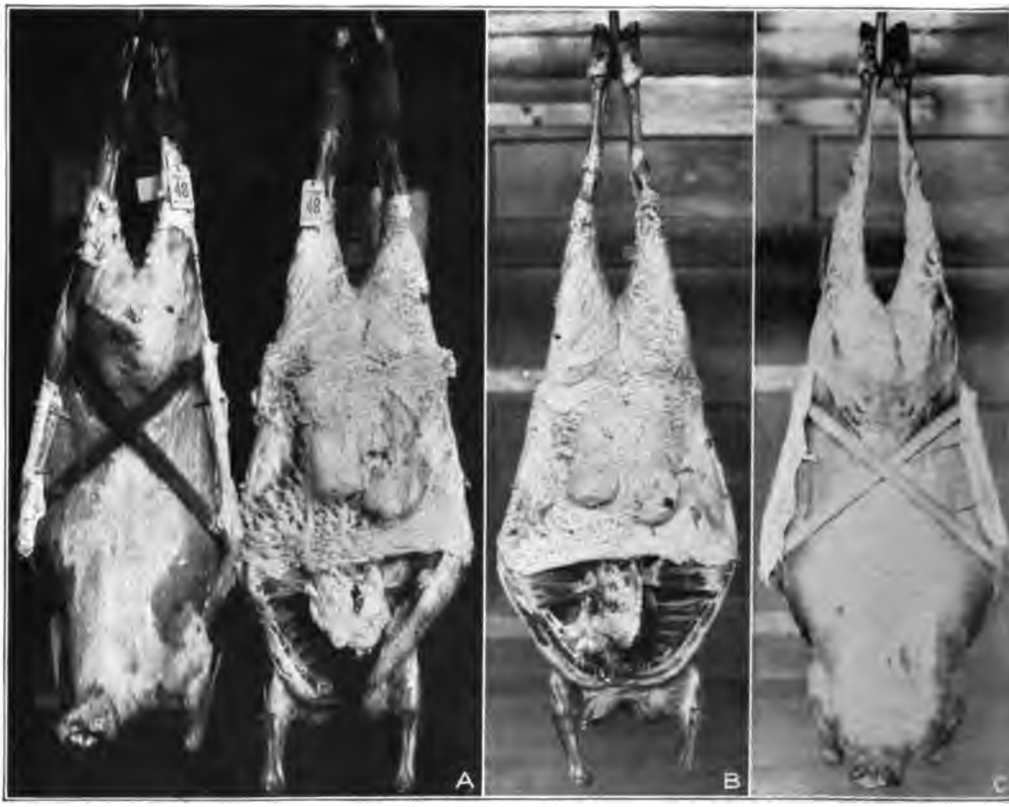

FIG. 46a. SPRING LAMBS.

Choice Good.

Easter lambs, a large proportion of which are consumed by the local Jewish and Greek population, who use them in connection with religious customs. For this trade, dressed lambs must show the effects of shelter, care and milk feeding, indications of which are thick, white flesh on the breast, flanks and legs, a good covering of fat on the kidneys and lining the crotch, fine shanks, red ribs and soft, white hench-bone. The carcass weight varies from 30 to 50 pounds, gross; the general run weigh 35 to 45 pounds and the most desirable weights are 35 to 40 pounds. Carcasses weighing less than 30 pounds are discriminated against, because their net round-dressed weight is less than 20 pounds, and quarters lighter than 5 pounds are too small to suit the retail trade. The variation in this class of lambs is not sufficient to separate them into distinct grades, altho prices vary somewhat according to weight and quality.

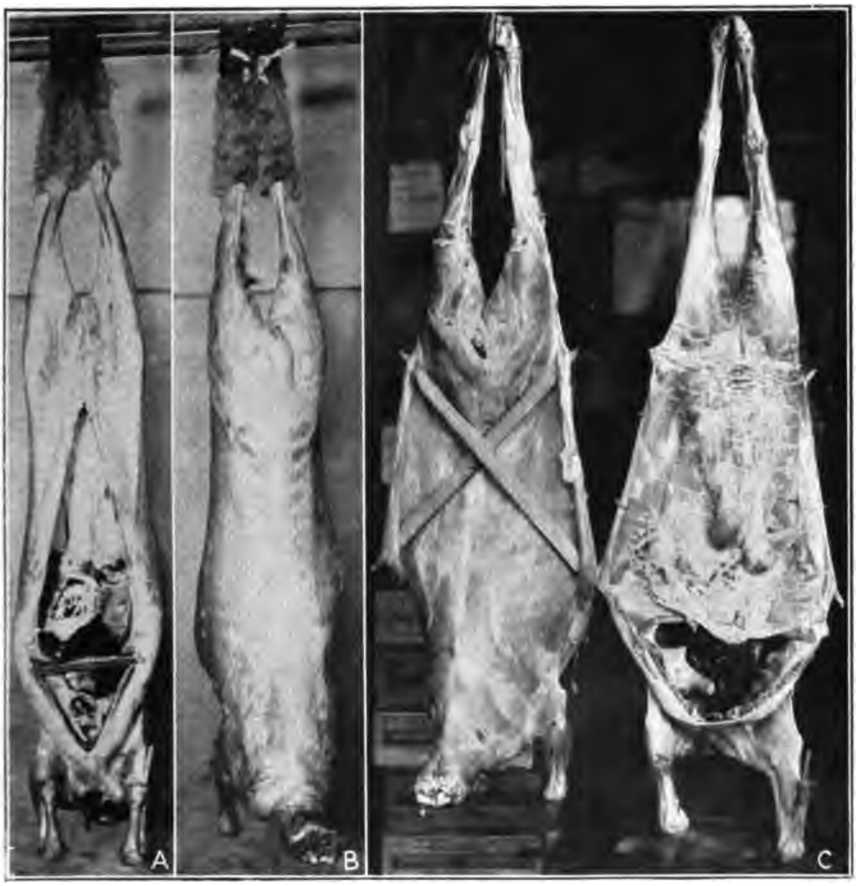

FIG. 46b. SPRING LAMBS.

Medium. **Common.**

After May 1 to 15 "genuines" are round- and caul-dressed, except special orders of pelt lambs. As the season advances more variation in quality and weight is found, and by July 1, this class is identical with the various grades of spring lambs described above. Average weights of caul- and round-dressed "genuines" are 20 to 35 pounds. They are usually dressed with the wool or "stockings" on hind shanks, and plucks in.

"Genuine" spring lambs are sold both per carcass and per pound in wholesale markets, early pelt-dressed lambs being most frequently quoted by the carcass. The principal demand for this class of lambs is among hotels, restaurants and clubs of the highest class. In retail markets they are generally sold by the quarter, and when cut into chops are sold by the cut rather than by the

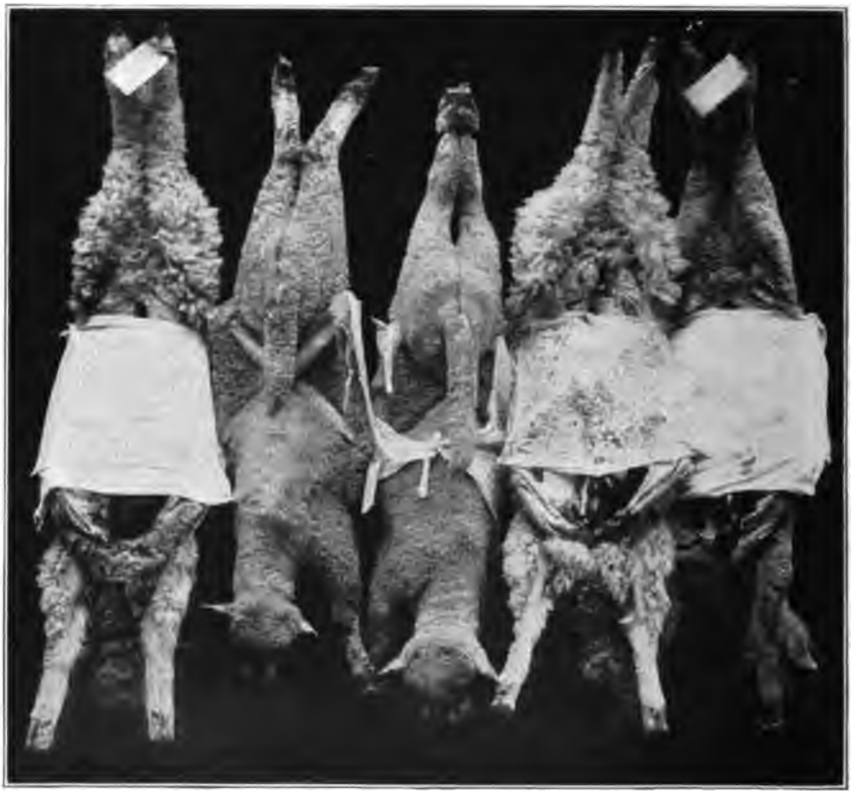

FIG. 47. "GENUINE" SPRING LAMBS.

pound. For this reason medium- and light-weight "genuines" frequently sell as high per carcass as heavy ones of the same quality. The supply of this class of lambs handled at Chicago is principally shipped from southern markets, especially Louisville and St. Louis. The number is comparatively limited and forms but a small percent of the supply of lambs marketed annually.

During July and August large numbers of choice, light spring lambs which resemble "genuines" are dressed "pelt on" and frozen to be held for the early lamb trade of the following winter and spring. They sell at about 25 percent below the price of "genuine springers".

WINTER LAMBS

Winter ("hothouse" or "incubator") lambs are light, young lambs which precede genuine spring lambs in the market by two or three months, being in season from January until May and a small number being available for Christmas trade. They are similar to

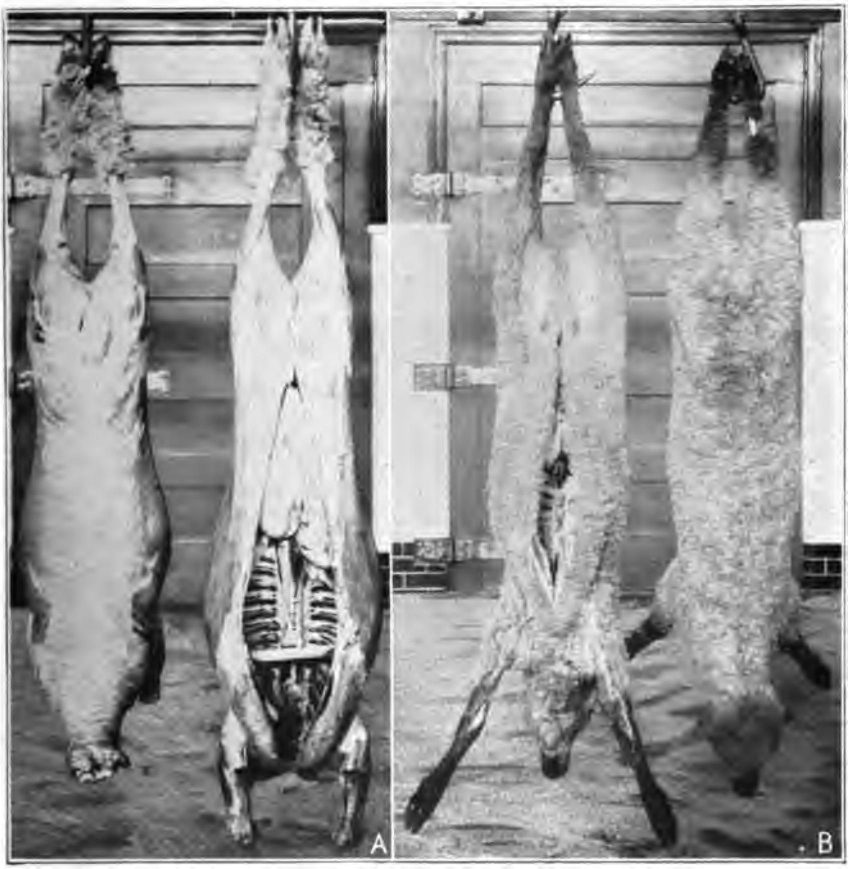

Fig. 48. Winter Lambs.

early spring lambs but are of lighter average weights and show better development in proportion to their age. They consist principally of native country-dressed lambs, six or seven weeks old, shipped from Wisconsin, Michigan and Illinois. They weigh 20 to 45 pounds and the bulk, 30 to 40 pounds, gross. They are dressed "pelt on" and "pluck in", with two back-sets and the caul placed over the belly. They are principally shipped to produce commission firms or direct to hotels, restaurants and clubs instead of passing thru the large wholesale markets. Being marketed in advance of the spring lamb season they sell at high prices and are taken by the most select trade. The few that are sold in retail markets are sold by the quarter and not by the pound. Frozen lambs put in storage at different seasons and in various sections of the country are also substituted for winter lambs, and sell at the same relative discount as frozen spring lambs. Late winter lambs and early "genuines" are practically identical classes. See Fig. 48.

KOSHER SHEEP AND LAMBS

Like calves and cattle, sheep and lambs sold to Jewish patrons are slaughtered, inspected and dressed under prescribed regulations (p. 188). The rack (12 ribs) only is used by this trade. Heavy mutton is not in demand in Jewish markets, and medium to choice lambs are the grades generally sold for this purpose. (See Easter lambs, p. 238).

SHIPPING MUTTON AND LAMB

The Chicago shipping trade in dressed sheep and lambs goes principally to cities in the eastern seaboard states. The largest percent of this trade consists of lambs. The mutton that is shipped consists of choice, good, and medium wethers, ewes, and yearlings. New York, Philadelphia and Boston are the leading markets to which heavy mutton is sent from Chicago.

Shipping lambs are dressed and graded according to the demands and customs of the various markets to which they are sent. The principal styles of shipping lambs recognized by the trade are as follows:

Regular, custom or Washington shipping lamb. Plain caul-dressed, pluck out. Medium and good grades, 35 to 40 pounds average. (Shipped to Washington and other cities and used locally). See Fig. 46a.

New York lamb. Pluck in, caul wrapped about legs in two pieces with heavy end upward, balance of caul placed from legs to kidneys. Medium and good grades, 35 to 40 pounds.

New York R. D. lamb. Round-dressed, pluck in. Choice lambs, 40 to 45 pounds.

Boston or B. B. (break-back) *lamb.* Ribs cracked and turned back, back broken, one straight back-set, shanks not folded, pluck out. Choice lambs, 40 pounds average. See Fig. 49. (Boston-style sheep are plain-dressed, but with the ribs cracked and turned back, and a spread-stick inside at the flanks. See Fig. 49.)

Philadelphia lamb. Pluck dropped thru caul, shanks folded. Medium to good grades, 35 to 40 pounds. See Fig. 49.

Baltimore lamb. Caul placed with heavy end upward, one back-set, pluck out. Medium lambs, 30 to 35 pounds.

Providence lamb (E. T. or Newport). Ribs cracked and turned back, 2 back sets, caul placed about fore quarters and around the back, pluck out. Choice lambs, 40 to 45 pounds. See Fig. 50.

Connecticut lamb (or New Haven). Round-dressed lamb,

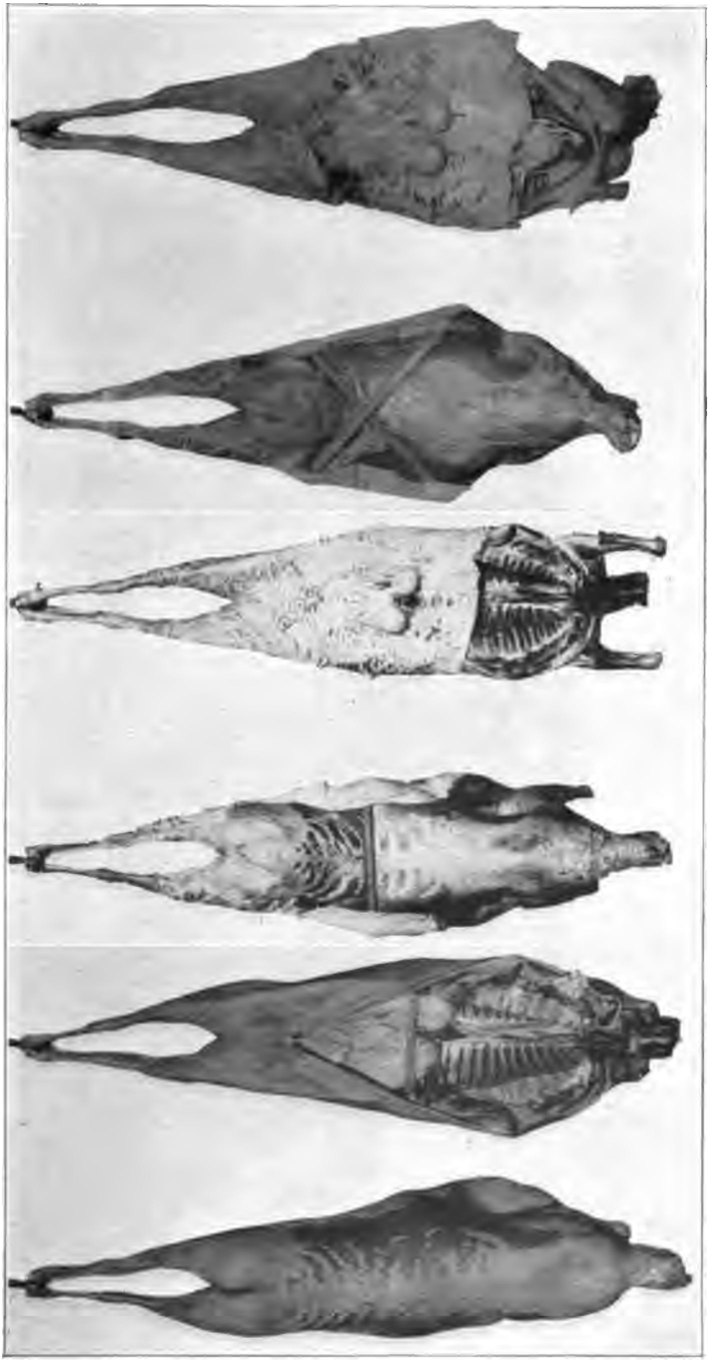

FIG. 49. SHIPPING MUTTON AND LAMBS.

Boston-Style Sheep. Boston-Style Lambs. Philadelphia-Style Lambs.

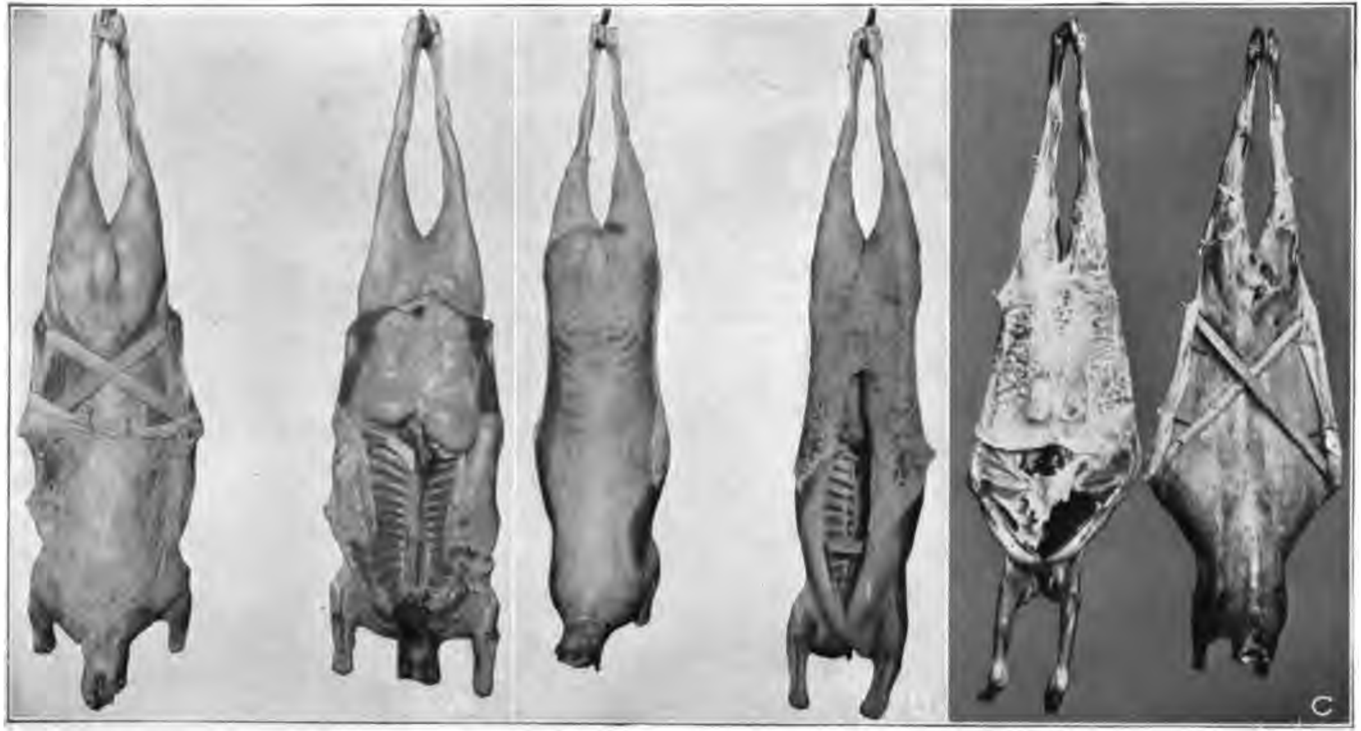

FIG. 50. A, PROVIDENCE STYLE LAMBS. B, CONNECTICUT-STYLE LAMBS. C, GOATS.

caul wrapped around hind legs and over belly with heavy end upward. Good lambs, 35 to 40 pounds. See Fig. 50.

Dressed sheep and lambs are not regularly exported from this country.

GOATS

Dressed goats are occasionally sold in connection with mutton and lambs and are frequently substituted for them, especially in retail markets. They are comparable in form, quality and finish with the lowest grades of Western sheep. Long shanks, coarse, dark flesh, long neck and thin caul, however, render them quite easily distinguished from sheep carcasses. They are not quoted in distinct grades. See Fig. 50.

MUTTON CUTS

About one-half the supply of dressed wethers, ewes and yearlings in large wholesale markets is sold as mutton cuts, consisting principally of saddles and racks as illustrated in Fig. 51. The carcass is usually divided between the twelfth and thirteenth ribs, yielding about 49 percent saddle and 51 percent rack. Subdivisions of the saddle and rack are quoted as wholesale cuts to some extent. The cuts derived from the saddle are the leg and loin, separated at the hip-bone and including two-thirds and one-third, respectively, of the weight of the saddle. The rack is made into a stew and a short rack by separating ten ribs (the third to twelfth inclusive) from the shoulder and breast as shown in the illustration. The short rack includes two-fifths and the stew three-fifths the weight of the rack. The short rack has the highest market value per pound of the wholesale cuts, and the legs, loin and stew are valued in the order named. Legs of mutton and lamb were formerly quoted and sold at higher prices than the ribs, but retail demand for the latter has during the last ten or fifteen years gradually overtaken and exceeded the demand for legs.

Grading Mutton Cuts

The grades of mutton cuts are *choice, good, medium* and *common.* Cuts of these grades correspond in shape, quality, covering and relative weight to the same grades of carcass mutton; and the descriptions of the latter will serve to indicate the more important differences that exist between the various grades of saddles and racks. The principles governing the grading of beef cuts (pp. 190 to 194) also apply in the main to the wholesale cuts of mutton, and should be studied in this connection. Thickness and quality of flesh and depth of covering are especially important, and the degree of each is readily determined by examining

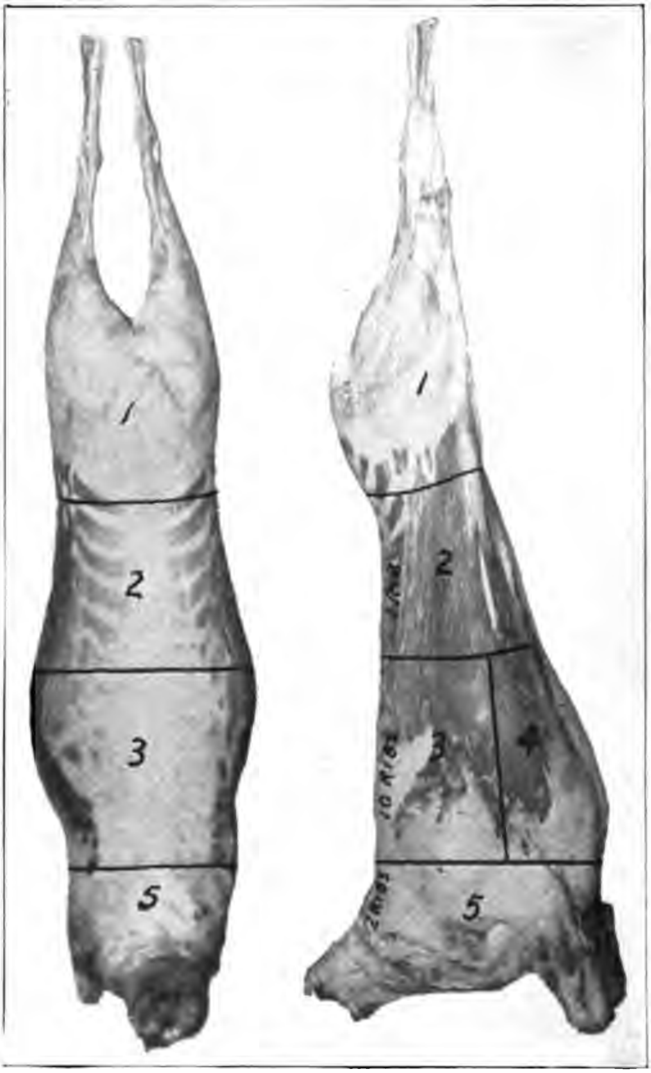

FIG. 51. MUTTON AND LAMB CUTS.

1, 2.	Saddle	1.	Leg	4.	Breast
3, 4, 5.	Rack	2.	Loin	5.	Chuck
1, 2, 3.	Long saddle	3.	Short rack	4, 5.	Stew
2, 3, 4, 5.	Body	2, 3.	Back		

the "eye of mutton" (the lean flesh covering the ribs and adjacent to the back-bone). It should be deep and well-rounded rather than flat. The color of lean varies from a dull brick red to dark red, the former being preferable. Fine fibre or grain, smooth, velvety surface and firm consistency of flesh are characteristics of choice mutton cuts. Marbling, or mixture of fat within the lean, is less developed and of less importance in mutton than in beef cuts.

SADDLES

Choice, good, medium and *common* saddles are illustrated in Fig. 52. It is seen that in shape, thickness and proportion of fat to lean the cuts are similar to the corresponding grades of carcass sheep. About one-fourth inch of fat over the loin is considered most desirable for choice saddles of medium weight. Since the legs make up two-thirds the weight of a saddle and sell at about one-sixth higher price per pound, the importance of that portion of the saddle is apparent. Aside from thickness and shape of leg and loin, saddles may grade low by reason of deficiency in general quality, as coarse bone or soft, uneven covering. The proportion of kidney-fat, its color and brittleness are also important factors. It is customary in most markets to quote mutton saddles by classes, as wether, ewe and yearling saddles, these being differentiated as explained in connection with those classes of carcass mutton. Weights of saddles commonly handled are 20 to 50 pounds, and the majority average 20 to 30 pounds. Choice and good saddles are, on the whole, somewhat heavier than medium and common grades.

Only a small percentage of saddles are cut up in wholesale markets. A "long saddle" consists of a regular saddle and short rack in one piece; in other words, it is the portion of a carcass that remains when a stew or chuck is cut from it. Legs and loins are cut principally from good and choice saddles.

RACKS

Regular or "market" racks are graded *choice, good, medium* and *common* (Fig. 52). Thickness and quality of flesh, proper thickness of covering on the back and ribs, and absence of coarseness are essential points in grading racks. The "eye of mutton" is of the same significance as in the case of saddles. The rib cut, or short rack, tho only two-fifths the weight of the rack, represents about two-thirds of its value and must be considered accordingly in grading. Quality and proportion of bone are indicated by the ribs and shanks, as in carcass mutton. The shape of neck indicates whether the rack is from a wether, ewe or buck. The range of weights is the same as that of saddles, viz., 20 to 50 pounds, with the bulk from 20 to 30 pounds.

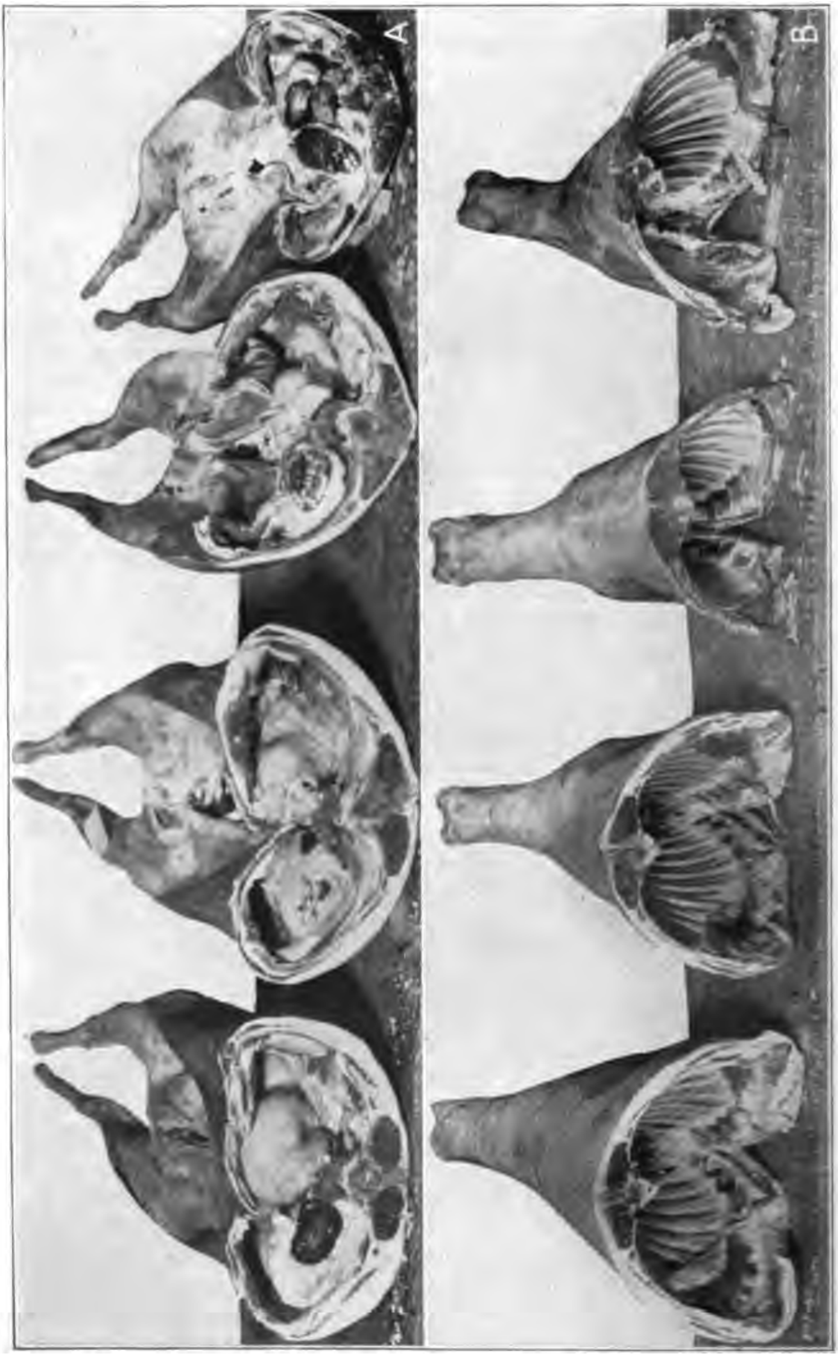

FIG. 52. A, MUTTON SADDLES. B, MUTTON RACKS. (CHOICE, GOOD, MEDIUM, COMMON.)

Short or "hotel" racks, or ribs, are made from medium to choice racks and graded similarly to them. They are cut 8 to 12 ribs long in various markets and in some cases are made "shoulder on," but usually contain only 9 or 10 ribs. They are quoted both "blade in," or regular, and "blade out" or "shoulder raised", a premium of one cent per pound being charged for the latter. As explained in describing beef ribs, the shoulder blade is a valuable indication of the age of the carcass and quality of the bone, being a white soft cartilage in young, well-fed sheep and gradually changing to bone according to the age and development of the animal. The high value of the short rack compared with other parts of the carcass is due to the demand for rib chops, which exceeds that for any other cut of mutton. Short racks are largely used by hotels, restaurants, dining cars, etc., for "French" chops, which consist of a rib chop with the end of the rib trimmed clean of flesh and fat, leaving only the "eye of mutton" with its covering and bone.

A mutton stew (chuck, wing, slug or rattle) is the shoulder, breast and shank in one piece, including nearly one-third of the carcass weight and two-fifths of the rack. The more important factors in determining their grade are thickness, grain and color of flesh and quality of bone indicated by the ribs, shanks and shoulder blades. This is the cheapest cut of the carcass, frequently selling at less than one-third the price of short racks and one-half that of legs of the same grade.

Fore quarters or "fores" are sometimes made from market racks by splitting them thru the back-bone. They are graded in the same manner as racks.

BACKS

Backs or "long racks" consist of a loin and short rack cut in one piece. They can be cut entirely into loin and rib chops, hence are well adapted to the use of restaurants, dining-cars, steamboats and high-class city retail markets. They are made chiefly from good and choice sheep. When cut in this style, mutton carcasses yield about one-third each of back, legs and stew.

A mutton body consists of a market rack and loin in one piece; in other words, the carcass with legs cut off. Sheep are not extensively cut in this fashion in wholesale markets.

LAMB CUTS

Lambs are more largely sold in the carcass than sheep, owing both to their smaller size and to the greater relative demand for the cheaper cuts of lamb than of mutton. It is estimated that one-fourth to one-third of the wholesale lamb trade consists of cuts.

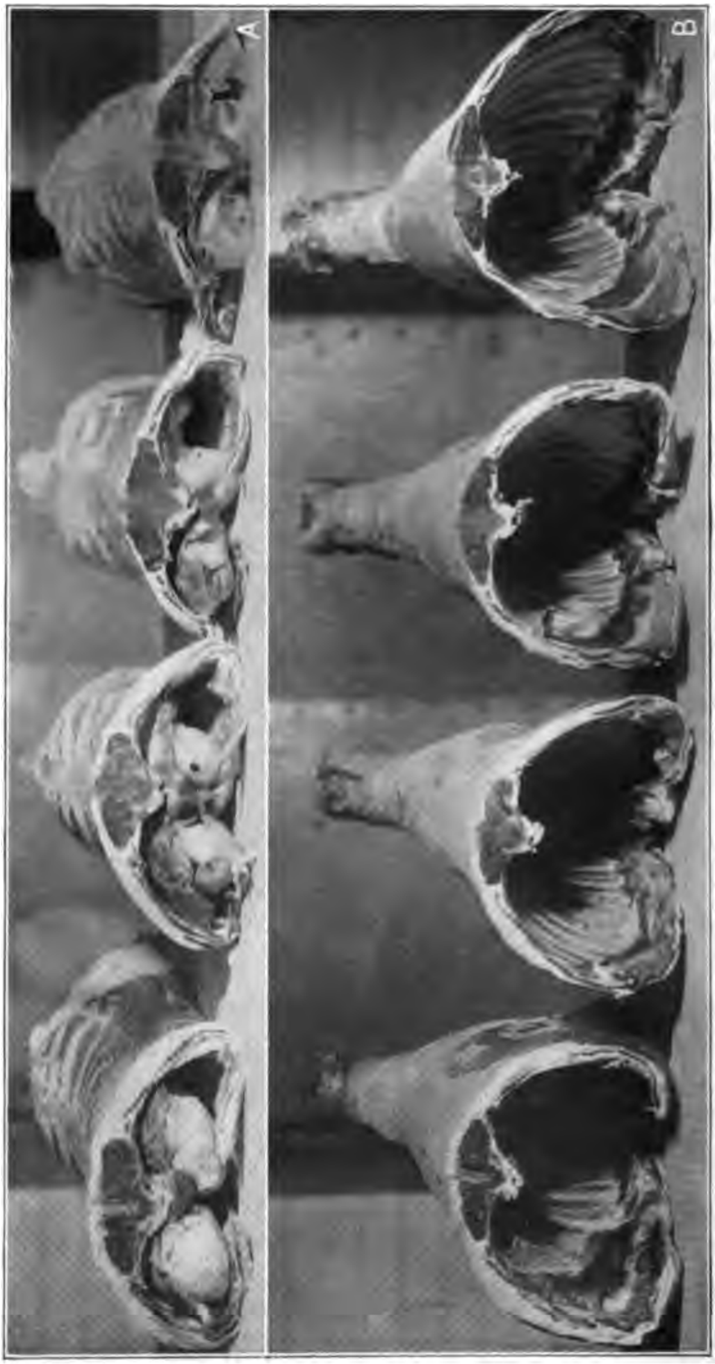

FIG. 53. A, LAMB SADDLES. B, LAMB RACKS. (CHOICE, GOOD, MEDIUM, COMMON.)

The methods of cutting and proportions of the various cuts are identical with those of mutton. Lamb saddles and racks, however, are still less commonly cut up than those of mutton.

The grading of lamb cuts is also similar in general to that of mutton cuts. About one-eighth inch of fat over the loin and ribs is desired in choice lambs, and a marked variation in either direction from this amount throws the cut into one of the lower grades according to the degree of excess or deficiency. The color of flesh in cuts of lamb is a lighter or more pinkish red than in mutton. The depth, grain and firmness of flesh and quality of bone are points of prime importance. As in mutton cuts the short rack has the highest market value, follcwed by the legs, loin and stew.

SADDLES.

The four standard grades of lamb saddles are illustrated in Fig. 53. The leg is the most valuable portion of the lamb saddle, representing about three-fourths of its total market value, consequently its fullness and covering are of great importance in determining the grade of a saddle. Kidneys of medium size, white and brittle, are required in choice saddles, together with the proper degree of finish as indicated by covering over loin and rump and the cod fat. Saddles are cut both from round- and caul-dressed lambs and principally from good to choice grades. Caul saddles are quoted below the price of round saddles of the same grade, and as a rule are made from a lower grade of lambs. Lamb saddles average 15 to 25 pounds and the bulk 18 to 22 pounds.

Lamb legs are also sold to some extent. They are taken principally from carcasses that are cut into legs, backs and stews, or legs and bodies. They are chiefly of good and choice grades and average 10 to 16 pounds per pair. A few good and choice loins are sold in most markets, but the proportion of saddles cut into legs and loins is much smaller than is true of mutton.

RACKS

Racks are graded *choice, good, medium* and *common* as illustrated in Fig. 53. Thickness and quality of flesh, especially over the ribs, depth and evenness of fat, and quality of bone as indicated by the ribs and shanks are the more important points considered. Like mutton racks, three-fourths of their value is contained in the short rack or rib cut, which yields the kind of chops that are most in demand.

Hotel racks and stews are made from market racks in the same manner as the corresponding cuts of mutton. They are graded as explained under mutton cuts, but a much smaller proportion of lamb than of mutton racks is thus handled. Fore quarters are also quoted but a still smaller proportion of "fores" than of other rack cuts is made.

BACKS

Backs or "long racks" of lamb, including the loin and short rack, are also made as in mutton. They may be made from any grade of lamb carcasses but are cut principally from the better grades. Lamb bodies, or carcasses from which the legs have been cut, are quoted but relatively few are sold.

PORK

Hog products may be described under three heads: (1) *Dressed Hogs,* (2) *Pork Cuts* and (3) *Lard.* As a rule, not more than one or two percent of the number of hogs slaughtered in large packing houses are sold as whole carcasses. Approximately three-fourths of the trade in hog products consists of various cured meats and fresh cuts, the remainder consisting principally of lard and a small percentage of sausage and canned meats. Further, fresh pork is of much less importance, relatively, than fresh beef or mutton, only about one-fifth of the domestic trade and five percent of the export trade in pork products (other than lard) consisting of fresh meat. Thus the classification of pork consists largely of cured and manufactured products, the number and variety of which renders the outline of this subject quite complex.

DRESSED HOGS

The classification of hog carcasses is based on the uses to which they are adapted, or the products into which they can be converted. The classes generally recognized and average weights included in each are as follows:

	CARCASS WEIGHTS
Smooth Heavy or Heavy Loin Hogs	240 to 400 lb.
Butcher or Light Loin Hogs	160 to 240 lb.
Packing Hogs	100 to 400 lb.
Bacon or Marked Hogs	90 to 170 lb.
Shippers	100 to 200 lb.
Pigs	20 to 100 lb.

Different styles of dressing are characteristic of the different classes of carcasses except heavy and light loin hogs, and shippers and pigs. Dressed hogs of all classes are cut open along the underline and thru the aitch-bone and brisket, but the method of splitting and trimming varies with the class, as follows:

Loin hogs are split down thru the centre of the back-bone ("loin-split" or "centre-split") in order that pork loins may be cut from the sides. They are dressed "packer style", i. e., head off* leaf out and hams faced.† See Fig. 54.

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*The jowls or cheeks are left as part of the carcass.

†Facing consists in trimming a strip of fat from around the face of the ham, so as to expose a larger lean surface.

Packing hogs are usually split like loin hogs, but are sometimes split on one side of the back-bone, making a "hard" and "soft" side. In either case they are dressed with head off, leaf out and hams faced.

Bacon hogs are usually cut ("marked") with a knife on each side of the back-bone, then split on one side and the back-bone taken out, making sides suitable for English bacon cuts. The head is taken off and leaf out, and the hams are either faced or not, according as they are intended for short-cut or long-cut hams. See Figs. 58, 59.

Shippers and pigs are dressed "shipper style", i.e., with head on, leaf in, back-bone not split and hams not faced. See Fig. 60.

Only shippers and pigs are extensively sold as dressed hogs. The other classes are cut up directly after being chilled, except relatively small numbers of butcher and packing hogs that are handled by jobbers or sold to retail dealers for fresh use.

Grading Dressed Hogs

The grades of hog carcasses are much less numerous and complex than those of carcass beef or mutton, owing to the greater variation in the latter with respect to age and general development. Standard grades are recognized only in the bacon and packing hog classes. In a broad sense, however, the six general classes may be regarded also as grades, since they are differentiated largely by shape, finish, quality and weight as well as by styles of dressing.

The shape desired in loin and packing hogs is great width of side and back in proportion to length of body, straight, even lines and well-filled hams and shoulders. In bacon hogs, length of side is more important, with less width and thickness of back in proportion to that of the side than in the grades of fat hogs.

Finish is indicated by the depth and evenness of fat covering the carcass, especially along the back and over the sides; also by the amount and quality of leaf fat.* It is essential that the fat be white and firm. The depth of covering and proportion of leaf fat desired are described and illustrated in connection with the various classes.

Quality implies firm, bright, smooth-grained flesh and solid, white fat evenly distributed over the carcass; smooth, thin, mellow skin free from wrinkles, blotches or bruises; moderately small, fine shanks and head; soft, red chine-bones, back-bone and brisket; and an absence of coarseness in general. Points of special importance in selecting dressed hogs are the development and quality of loins and sides, and the size, shape, firmness and covering of the hams. Coarse or extremely large shoulders, neck and jowls, are indications of stagginess, and "seedy"* sows are classified as packing hogs because of their coarse quality.

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*The leaf is the internal fat of the carcass. It includes the kidney fat and extends down to the flanks and skirt (diaphragm).

The importance of weight in grading dressed hogs varies according to the class, as will be observed in the weights given on page 252 and in the following descriptions. In general, weight is a very important factor, and in the case of loin hogs it determines not only the grade but also the class to which a carcass belongs.

SMOOTH HEAVY OR HEAVY LOIN HOGS

These are prime smooth hogs, either barrows or good, clear (not seedy) sows, weighing 240 to 400 pounds, with from four to six inches of fat on the back; thick, wide, level sides without depressions in the back; heavy hams, filled out even with sides, full at the rump and well rounded down toward hocks, without

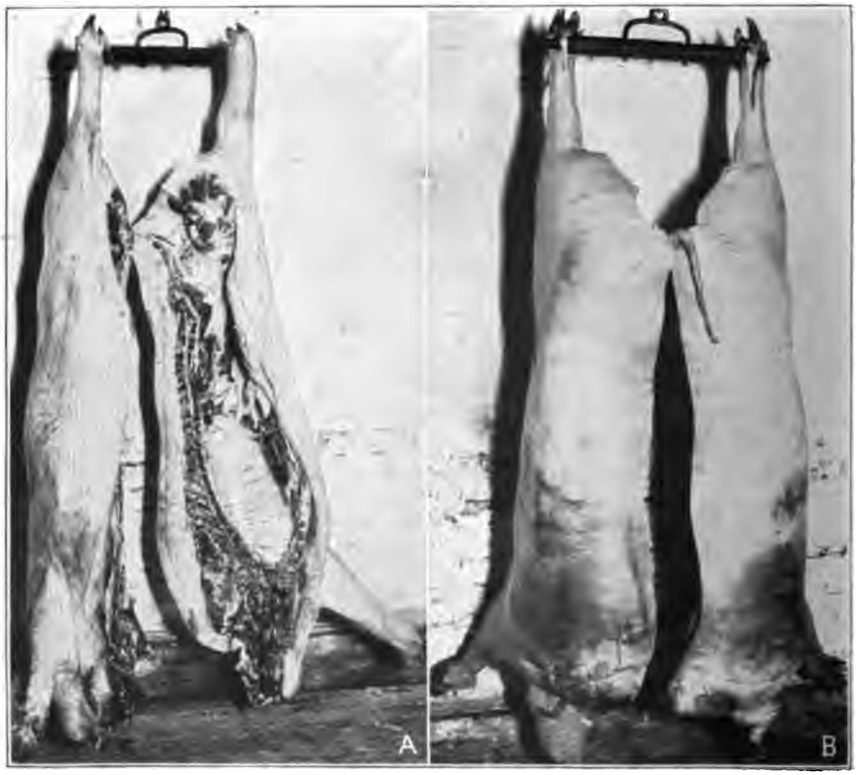

FIG. 54. SMOOTH HEAVY HOG.
Inside. **Outside.**

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*This term refers to the nipples or teats of sows that have borne pigs or reached an advanced stage of pregnancy. See Fig. 56.

wrinkles or flabbiness; smooth shoulders; short, full neck; and full but not coarse jowls. The skin must not be thick, hard, nor wrinkled. The flesh and fat must be deep, firm and even, the flesh bright-colored, the fat white and bones not coarse. As their name indicates, such hogs are especially suitable for making heavy loins, the remainder of the side being made into a heavy fat back and dry-salt belly. However, under certain market conditions they are cut into the same products as heavy packing hogs. The hams are usually skinned and the shoulders cut into picnics, butts and plates. Hogs of this class are a very small percent of the supply. See Fig. 54.

BUTCHER OR LIGHT LOIN HOGS

The term "butcher" refers to "butcher shop" or retail family trade. A large proportion of the fresh pork sold in retail markets is pork loins, which are cut into chops and roasts; hence light loin or "pork loin" hogs are those from which these cuts

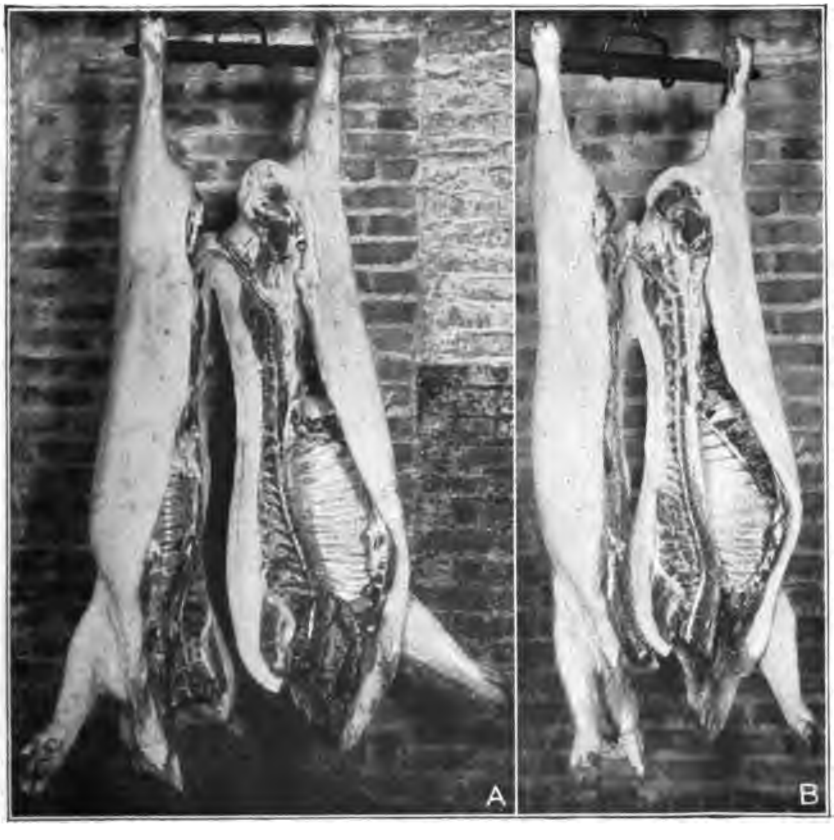

FIG. 55. BUTCHER HOGS. A, HEAVY. B, LIGHT.

can be obtained to best advantage. To yield loins of the proper size and quality, a hog carcass should weigh about 160 to 240 pounds and have the same shape, smoothness and general quality described above with reference to heavy loin hogs. Thick, firm flesh, smooth, soft skin and solid, white fat are especially important. The covering of fat should be two to four inches thick on the back. This class is composed of barrows and smooth, clear sows. The weights most preferred for butcher hogs are 200 to 220 pounds. They are principally cut up by packers, the loins being sold to retail dealers or jobbers. Besides loins, fat backs, clear bellies, extra ribs and extra short clears are commonly made from sides of butcher hogs. The hams are cut short and the shoulders principally made into picnics, New York-cut shoulders and Boston butts. In some instances, carcasses of this class are sold to retail markets for fresh trade, in which case they are dressed either "head on" or "head off" as ordered. See Fig. 55.

PACKING HOGS

This class includes mixed hogs of all weights which are too coarse in quality, rough in shape or soft and uneven in finish to

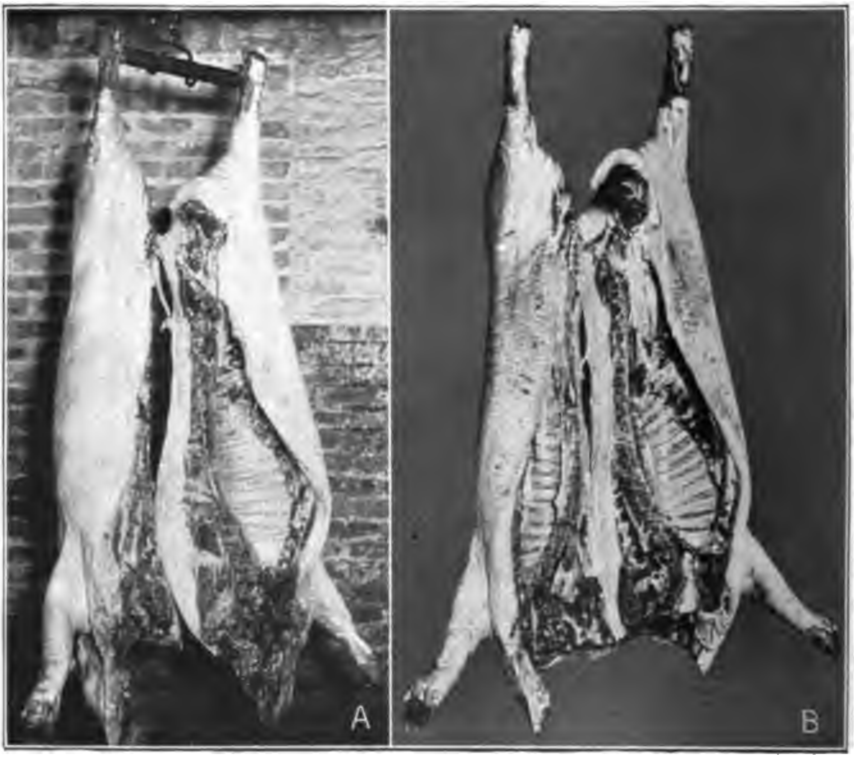

FIG. 56. PACKING HOGS (SOWS). A, HEAVY. B, MEDIUM.

be suitable primarily for fresh pork products or smoked meats and are therefore principally packed in such forms as barreled pork and dry-salt meats. About one-half the hogs handled in Chicago packing houses belong to this class.

Heavy Packing Hogs, also known as Rough Heavy or Mess Pork Hogs, consist of rough and seedy sows, coarse barrows, boars and stags averaging 240 to 400 pounds. All heavy hogs that are too rough to be classed as loin hogs are included in this grade. Defects common to these carcasses are thick, rough and wrinkled skin, dark-colored and coarse-grained flesh, soft, oily fat, large bones and carcass bruises. (Figs. 56, 57.) They are more largely cut into short ribs and mess pork, and less into loins, fat backs and bellies than Heavy Loin Hogs, and consequently are more frequently "marked" and side-split altho at times

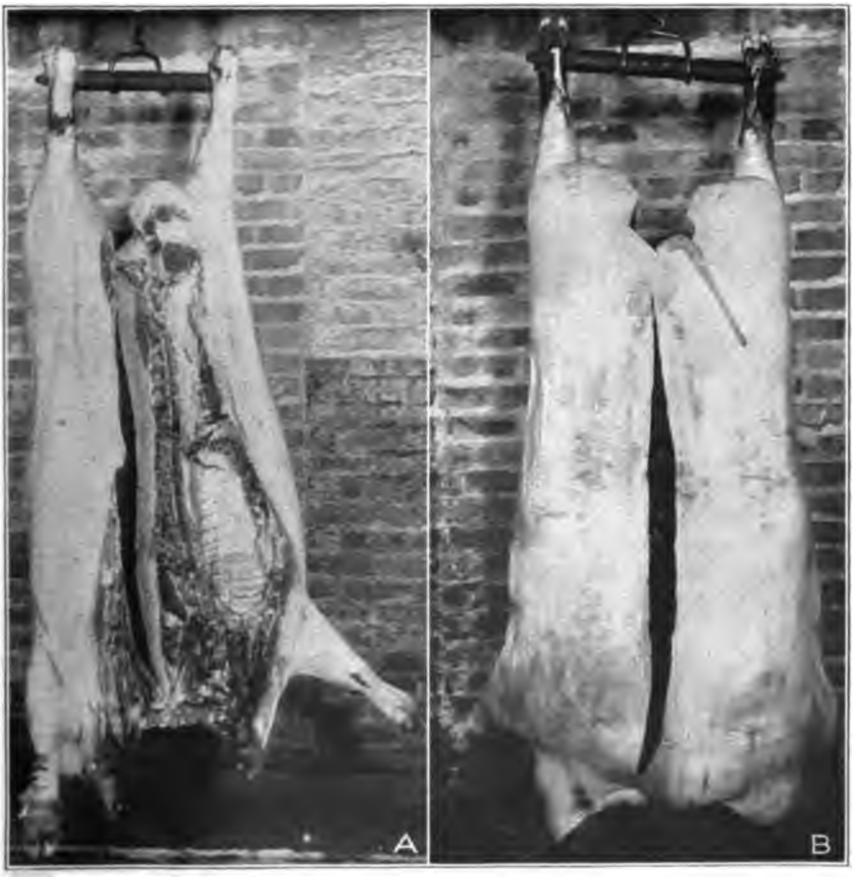

FIG. 57. PACKING HOG (BOAR).

Inside. **Outside.**

a large proportion of them are loin-split and pork loins taken out. The hams are sweet pickled and shoulders made into picnics and Boston butts.

Medium Packing Hogs are sows and barrows averaging 200 to 240 pounds that are inferior to butcher hogs in quality; they also include a small proportion of stags and boars. (Fig. 56.) The cuts made from this grade are dry-salt sides, mess pork, clear backs, dry-salt and "English" bellies, pork loins, short-cut hams, and New York cut and picnic shoulders.

Light Packing Hogs are mixed hogs of 100 to 200 pounds weight that are too deficient in shape, quality and finish to be classified as either Bacon, Butcher or Shipper hogs. This grade consists largely of light sows. They are cut into prime mess pork, short clear backs, clear bellies, short-cut hams, and picnics, New York and skinned shoulders.

BACON OR MARKED HOGS

Bacon hogs are those that are suitable primarily for sugar-cured breakfast-bacon bellies and "English" meats. Since such meats must be comparatively lean, firm and of good quality, the leading features of bacon hogs are long, deep, smooth sides with a light, even covering of fat over the entire carcass and especially uniform on the back and sides. The hams should be full but lean and the shoulders light and smooth. The flesh must be firm and not "watery", the fat solid and the carcass sufficiently mature to insure proper curing. Hogs which fulfil these conditions weigh 90 to 170 pounds dressed. Low grades of bacon are made from pigs as light as 60 or 70 pounds, but the most desirable weights are 120 to 150 pounds. They consist principally of barrows, but for most grades of bacon smooth, clear sows that resemble barrows in general quality and finish are used to some extent. Only a small percentage of the dressed hogs handled at Chicago are of this class. The products principally made from them are "English" middles, backs and bellies, domestic breakfast-bacon bellies, long-cut and short-cut hams. Bacon hogs vary from choice to common in quality, finish and shape, and altho no fixed grades are universally recognized among packers, they are usually designated as *choice, good* and *common,* respectively.

Choice bacon hogs must be evenly fleshed and covered with a smooth layer of fat over the loin, shoulders and sides. Firm flesh, solid, white fat, and a white, smooth skin are especially important in this grade. The depth of back-fat is from one and one-fourth to two inches. It must be evenly distributed, however, not varying more than one-fourth or three-eighths of an inch at different points on the back and shoulders. Large sides of even width are

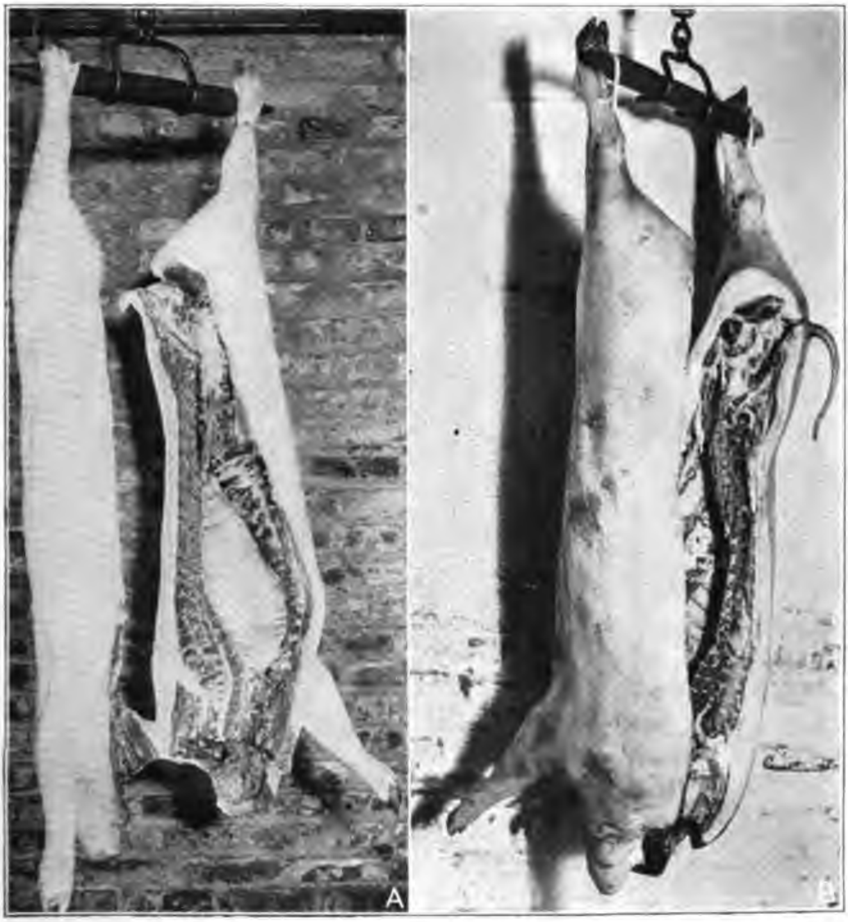

FIG. 58. CHOICE BACON HOGS.

also essential. This grade is used for the manufacture of "Wiltshire" and "Staffordshire" sides, "English" backs and bellies, and fancy breakfast-bacon bellies, also "Cumberland" sides to some extent. They weigh about 120 to 160 pounds, and only barrows are generally used. See Fig. 58.

Good bacon hogs include those that either lack the prime finish required of the highest grade or are too thickly or unevenly covered with fat; also those that are slightly deficient in length and depth of sides, or firmness and quality of flesh and fat. This grade, therefore, contains a much larger variety of carcasses than the choice grade, but they must nevertheless be reasonably well suited to the manufacture of smoked bacon and English meats. The thickness of back-fat must not be less than one nor more than

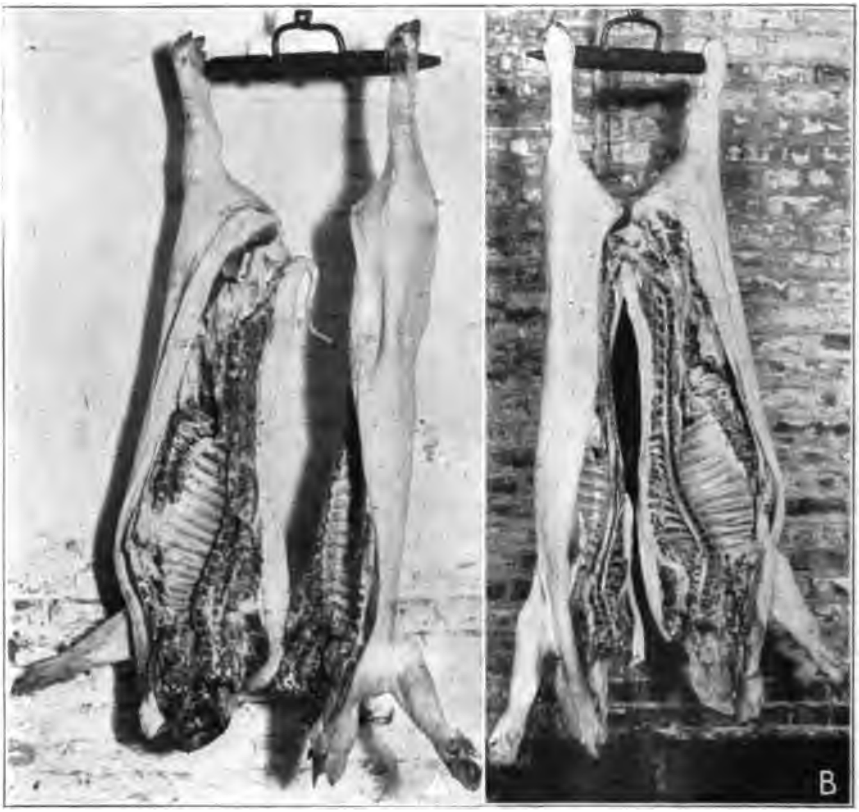

FIG. 59. BACON HOGS.
Good. Common.

two and one-half inches. Average weights vary from about 110 to 170 pounds. "Cumberland", "Wiltshire" and long clear sides, "English" bellies and domestic breakfast-bacon bellies are made from this grade. See Fig. 59.

Common bacon hogs are below the average in finish, quality and weight. Tho a hog may have the proper amount of fat, if it is unevenly distributed over the back and belly and not well mixed with the lean, the sides are not adapted to making good bacon. Carcasses that are too fat to grade as good bacon hogs are classified as packers rather than common bacons. The latter are principally light unfinished carcasses, the poorest of which are so thin as to be known as "skippy" or "skinny" hogs.

The grade also includes some that have sufficient fat and weight but are soft and dark-colored in their flesh and fat and coarse in general appearance. Average weights of this grade are 90 to 110 pounds but a few range from 60 to 130 pounds. Common to medium bacon hogs weighing 90 to 130 pounds are used for long rib sides, and 60 to 110-pound averages are made into Dublin middles. The latter, tho of the same weights as heavy pigs, are generally distinguished from them by darker colored flesh and harder, whiter bones. See Fig. 59.

SHIPPERS

Shippers are similar to Butcher Hogs in shape and quality but are lighter in weight and generally not as highly finished, having only a moderate covering of fat and a comparatively small amount of leaf fat. As compared with Bacon Hogs they are shorter and thicker-bodied, have a deeper and less even covering of fat, heavier jowls and show less age in proportion to their weight and general development. They average 100 to 160 pounds and are dressed "head-on". (Fig. 60.) Since their chief use is for fresh retail trade they must be carefully selected, and carcasses of this weight that show a marked lack of quality such as thick, rough skin, coarse bones, dark color or very uneven covering are classified as light packing hogs. This is the only class of hogs that is extensively sold in the whole carcass. They are shipped in car lots to eastern points, especially New York City, Boston, Buffalo and various New England cities, where they are used both for fresh retail trade and for the manufacture of "home-packed" meats.

The term "shipper" is also applied by some packers to all other carcasses that are dressed "shipper style", and they are quoted in weights from 40 to 280 pounds. In this case, carcasses heavier than 160 pounds are selected from Loin Hogs, and those lighter than 100 pounds are the class described below as Pigs. Heavy hogs quoted in this way are bought principally by retailers in small cities and towns, but the trade is very limited and has been largely replaced by pork loins. Shippers of all grades are sold most extensively during the winter months, when demand for fresh pork is greatest.

PIGS

Pigs are carcasses of light young swine that are comparatively lean and light colored in flesh, with thin, soft skin, soft red bones, and weighing from 20 to 100 pounds. They are dressed "shipper style" and are often quoted together with Shipper Hogs. Thin and coarse or staggy pigs are frequently termed "throwouts". Pigs are chiefly used for fresh trade in small retail markets, where the heavier grades are cut into chops, pork steaks, hams and other fresh cuts, and the smaller carcasses are retailed to certain laboring classes by whom they are used for boiling pur-

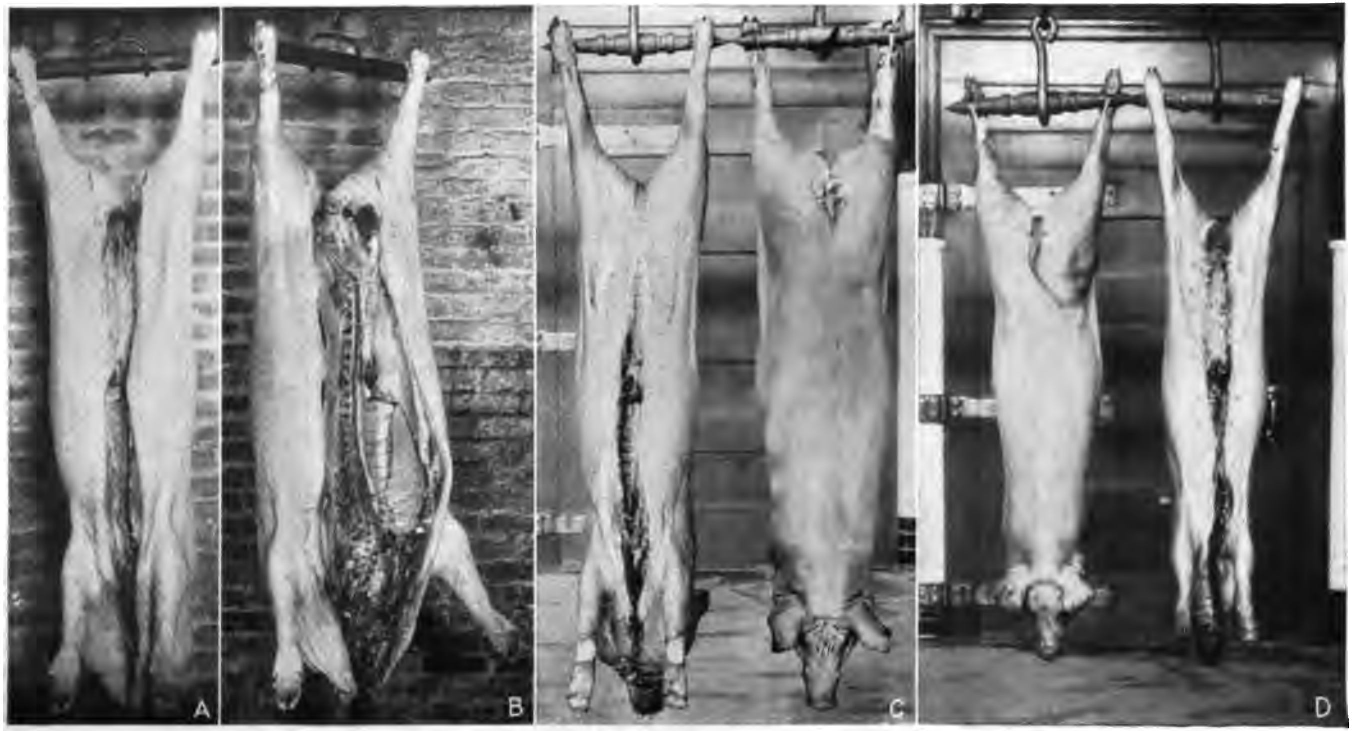

FIG. 60. A, B, SHIPPER HOG. (B, SPLIT TO SHOW INSIDE.) C, GOOD PIGS (60 lb.) D, COMMON PIGS (20 lb.)

poses. New York is the leading shipping point for 80 to 100-pound pigs. The mining districts of Pennsylvania take many of the lighter averages, 60 pounds and under. "Export pigs" are selected carcasses of choice quality averaging 80 to 100 pounds, dressed "head off" and wrapped in muslin. See Fig. 60.

Roasting Pigs are dressed suckling pigs which are fat and smooth, with white skin and flesh indicating a well-nourished condition. They are country-dressed, as a rule, with head on and the carcass opened only from the crotch to the brisket. Roasters are principally shipped like winter lambs direct to the hotels and restaurants that use them. The most desirable size is 15 to 20 pounds but pigs weighing 10 to 30 pounds are used.

PORK CUTS

The various cuts made from dressed hogs may be divided into the following general classes: *Hams, Sides, Bellies, Backs, Loins, Shoulders, Butts and Plates* and *Miscellaneous.* See Fig. 61.

These products are quoted and handled according to the manner in which they are prepared or packed viz., Fresh Pork Cuts, Dry-Salt and Bacon Meats, Barreled or Plain-Pickled Pork, Sweet-Pickled Meats, Smoked Meats, "English" Meats and Boiled Meats. It will be necessary to define these terms before attempting to describe the grades and uses of the different classes of cuts.

Fresh Pork Cuts are sold either chilled or frozen. The bulk of the uncured product is disposed of within a few days after slaughter, during which time it is chilled at temperatures slightly above the freezing point. Freezing is employed for the storage of pork loins and other fresh cuts and edible offal when supply exceeds demand, and in some cases for keeping bellies, hams, shoulders and other cuts intended for future curing. Frozen pork, however, is not quoted nor handled to the same relative extent as frozen beef and mutton. Cut meats may also be kept without curing by packing in brine and storing at about 15° F., until it it desired to cure them in the regular manner. Cuts packed in a light brine and kept slightly above the freezing point for a short time are sometimes sold as "partly cured" meats.

Fresh pork cuts are taken more or less from all classes of hogs. Since the pork loin is by far the leading fresh cut, light loin hogs are more extensively used for fresh pork than any other class. The varying demand for loins determines to a considerable extent the method of cutting other classes of hogs from time to time. Tenderloins and spareribs are also primarily fresh cuts. Skinned shoulders, shoulder butts, hams, bellies, fat backs, and raw leaf fat are sold fresh to a small extent. Some packers pur-

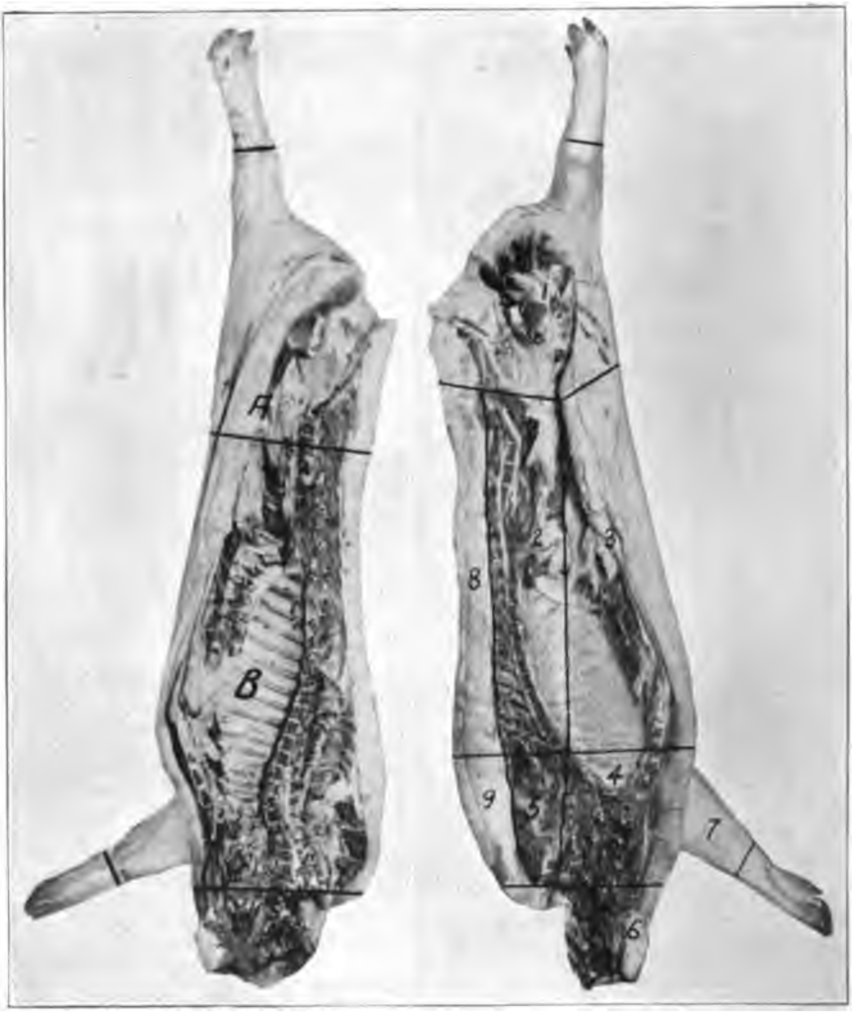

FIG. 61. PORK CUTS.

ENGLISH CUTS
A. Long-cut ham
B. Long side or middle

DOMESTIC CUTS

1.	Short-cut ham	6.	Jowl	2, 3, 8.	Side
2.	Loin	7.	Hock	4, 7.	Picnic shoulder
3.	Belly	8.	Fat back	5, 9.	Shoulder butt
4.	Picnic butt	9.	Clear plate	8, 9.	Long fat back
5.	Boston butt	2, 8.	Back	4, 5, 7, 9.	Rough shoulder

chase their raw material in the form of fresh cuts, such as bellies, hams, picnics, leaf and back fat, and convert them into smoked meats, lard and other products bearing the trade-mark of the packer.

Dry-Salt Meats are domestic cuts made from heavy fat packing and loin hogs, cured and shipped in coarse salt, and with a few exceptions, pumped* before salting. These are distinct from "English" meats both as to selection and packing. The cuts that are sold in this form are heavy sides, bellies, shoulders, fat backs, plates and jowls. The same cuts, and particularly bellies and short clear sides, are also quoted as bacon meats, which, after being cured in dry salt are smoked before shipping. The term *Bacon,* when used as a prefix, refers to dry-salt meats, while *Smoked Meats,* as described below, are cured in sweet pickle. Dry-Salt and Bacon Meats are generally shipped loose, but are sometimes put up in boxes containing 25 to 500 pounds.

Barreled or Plain-Pickled Pork is packed in plain salt brine in tight barrels (18″ x 29″) at 200 pounds net weight of cured pork per barrel (355 pounds gross). The strength of brine is varied somewhat according to the cuts of pork and their destination. The regulation of the Chicago Board of Trade governing standard barreled pork (except prime mess) is as follows: "Between October 1, and the last day of February,† inclusive, 190 lbs., and between March 1st and September 30th, inclusive, 193 lbs., of green meat........shall be packed in each barrel, with not less than 40 lbs. of coarse salt and barrel filled with brine of full strength; or 40 lbs. of coarse salt and in addition thereto 15 lbs. of salt and barrel filled with cold water". Standard prime mess pork is packed 20 pounds salt and 12 ounces of saltpetre per barrel, otherwise as above. Barreled pork is made largely from sides of *Packing* and *Heavy Loin Hogs,* and consists principally of mess, fat back and belly pork of various grades. A much smaller proportion of the pork supply is barreled than formerly.

Sweet-Pickled (S. P.) Meats are cured in sweet brine. Standard cuts of this class are packed as follows for delivery on the Chicago Board of Trade: "300 lbs. block weight shall be packed in each tierce with either 22 lbs. of salt, 3 quarts of good syrup,

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*Brine is injected into the meat by means of a perforated hollow needle attached to a force-pump.

This period of 5 months is known in the pork trade as the "winter packing season", and the balance of the year as the summer season. Formerly, wholesale pork packing was limited almost entirely to the winter season, but with improved facilities packers now handle about three-fifths of the annual supply during the "summer season".

12 ounces of saltpetre and tierce filled with water, or tierce filled with sweet pickle according to above standard". Various modifications of this formula are used for meats not intended for regular delivery. After curing, sweet-pickled meats are commonly packed in slack barrels or boxes, or sold loose, but are also sold in tierces (21" x 32"), either "pickle on" or "drained". The bulk of sweet-pickled and other sugar-cured meats are smoked before they reach the consumer, as explained in the following paragraph. A percentage of heavy sweet-pickled hams, picnics and loins are also boned out and sold as "boiled meats", which are described below. The cuts that are quoted as sweet-pickled meats are hams, picnics, New York cut and skinned shoulders, boneless butts, light bellies, and spareribs. This class of meats is cut principally from Butcher Hogs and from medium and light Packing Hogs; hams and picnics from all classes of hogs are generally sweet-pickled.

Smoked Meats are sweet-pickled as described above and smoked after curing. They also include light breakfast-bacon bellies that have been dry-cured in salt and sugar. In packing smoked meats, fancy hams and breakfast-bacon bellies are wrapped in "parchment" paper or canvas and packed in 50 and 100 pound boxes and crates. Other grades are sold either unwrapped, canvassed, or wrapped in burlap, and either loose, boxed or crated (100 to 500-pound packages) or packed in slack barrels or burlap sacks.

"English" Meats is a term applied to certain cuts that are dry-cured in English salt and saltpetre and primarily adapted to English trade, being given a milder cure than domestic meats. They are made principally from Bacon Hogs. The leading cuts of this class are "English" bacon sides, long-cut hams, clear backs and bellies, and square shoulders. After curing, these cuts are packed in borax or salt in 500 to 550-pound boxes for export. Borax is principally used, but a small proportion of "English" cuts such as long clears are shipped in salt, which continues the curing process during shipment. English meats are generally dried or smoked lightly after their arrival at British ports before being sold. Meats cured by this process are used to some extent in this country, being quoted as "English-cured". Sweet-pickled meats are also shipped in borax to England in considerable quantities.

Boiled Meats consist of hams, picnic shoulders and loins cured in sweet pickle, cooked in water and lightly smoked. The cuts are usually boned and the fat trimmed off within one-half to one inch of the lean before cooking. Boiled hams and shoulders are generally quoted as "rolled boneless" cuts, which are pressed in a cylindrical form, or rolled and tied with cord. Three loins are tied together for boiling, making a "loin roll". Boiled meats are made principally from the heavier cuts but various averages are used, including 12 to 30-pound hams, 10 to 14-pound picnics and 14 to 24-pound loins. The boning and fatting reduces the weight of hams about 25 percent and of loins, about 60 percent.

Grading Pork Cuts

The grading of pork cuts is more complex than that of other meats since it involves not only their quality, shape, proportions of fat and lean, and weight, but also the styles of cutting and methods of packing by which they are prepared for different classes of trade. Many of the grade names refer merely to different methods of cutting and curing; but since they are applied only to cuts of specified quality, thickness or weight, the grades are in reality based on the latter factors to a large extent. The various cuts differ considerably as to methods of grading; consequently an adequate explanation of the factors involved and their relative importance can be presented only by describing the grades of each class.

HAMS

Hams are of two general kinds, short-cut and long-cut. The former are made from comparatively fat, plump hams, trimmed short and round at the butt, and the shank cut off at the hock joint. They are sold either as *Regular Short-Cut, Skinned,* or *Boneless Rolled Hams.* Long-cut hams are lean, long hams, with the butt left full and the foot taken off at the first joint below the hock. The principal grades are *Regular Long-Cut, Stafford Cut, Manchester Cut* and *Italian Cut Hams.*

Short-Cut or *American Cut Hams* are cut from the side midway between the hench-bone and slip-bone,* trimmed round at the butt, cushion† faced full, not undercut on the skin side, and shank cut off in or above the hock joint. Until 1909 the Board of Trade required that the shank be cut above the hock so as to expose the marrow. Practically all hams are sold as sweet-pickled or smoked meats. For regular delivery on the Chicago Board of Trade as sweet-pickled hams, they must average, in lots, not to exceed 16 pounds, with no ham to weigh less than 12 pounds and none to weigh over 20 pounds. The short-cut ham is the leading ham cut and has to a large extent taken the place of the long-cut ham in export trade.

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*The hench-bone is the flat portion of the hip-bone that remains attached to the socket joint of the ham when the hog is split. The slip bone is the portion of the hip-bone that lies in contact with the back-bone near the end of the loin.

†The cushion is the fat butt of the ham where the tail piece is cut off.

Short-Cut Hams are graded by packers according to the brand of smoked hams for which they are suitable. For the first brand (known as "extra selected" or "fancy" sugar-cured hams), they are selected for thickness and firmness of lean meat, plump, well-rounded shape, solid, white fat of medium thickness (1¾ to 2 inches on a medium-weight ham), smooth, soft skin, bright color, small shank and absence of bruises. The bulk of this grade weigh 10 to 16 pounds, 10 to 12 pounds being most desirable for family trade, and 14 to 16 pounds for hotels and restaurants. They are cut mainly from Butcher Hogs. Especial care is taken in curing and smoking to secure the proper flavor and color. See Figs. 62, 64. Second brand or second grade hams (frequently termed No. 1's) are deficient in one or more of the points just mentioned, but must be reasonably good in general quality and not exceedingly deficient in any particular. Many of them are too fat for the first brand. They may be cut from any class of hogs but the majority are made from Packing hogs. See Fig. 62. The third brand (also known as "seconds"), includes those from which a skin-bruise has been removed, also thin, light hams and any others which lack the shape and quality required for regular meat market trade. They are cut from Packing and Common Bacon Hogs. See Fig. 62. "Easter Hams" are light, lean hams (6 to 10 pounds) of good shape and quality but cut from smooth young pigs. They are sugar-cured and smoked and are in season during the spring and early summer.

Skinned Hams are cut short as explained above, the skin is removed down to the shank and the fat trimmed off within one inch of the lean. Until 1909 the Board of Trade regulation required the fat to be trimmed off within one-half inch of the lean. They are made from fat hams of first and second grades, weighing from 12 to 30 pounds, but the bulk weigh 16 to 22 pounds. Many skin-bruised hams are also skinned in order to remove bruises. This style is especially adapted to making boiled hams, which are in favor with restaurant trade for slicing. From one-tenth to one-fourth of the wholesale supply of hams are skinned under usual market conditions. They are quoted both as smoked, sweet-pickled and boiled meats. See Fig. 62.

Boneless Rolled Hams are made from sweet-pickled short-cut hams by lifting the skin, removing the surplus fat and the bone, and pressing or tying in the form of a roll with skin on. They are also made from skinned hams. 15 to 26-pound hams of first and second brands are used, and they are sold as boiled meats. See Fig. 65.

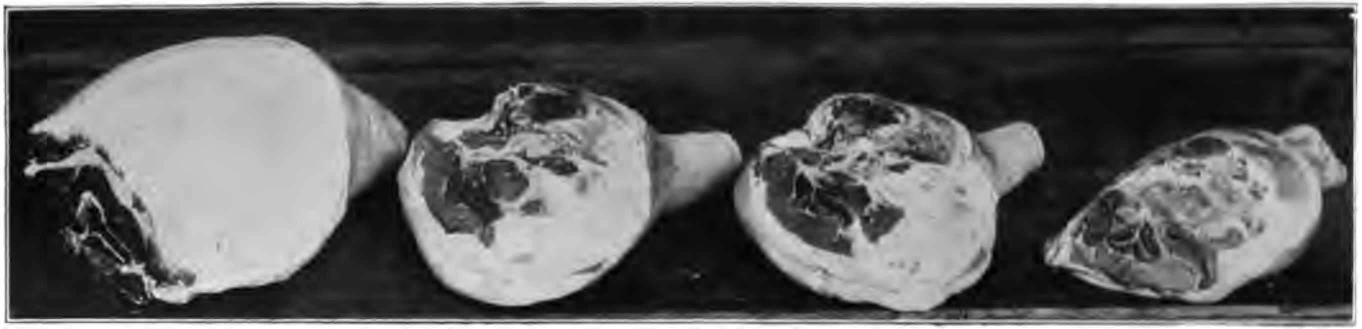

FIG. 62. SHORT-CUT HAMS.

Skinned Ham. Second Brand. First Brand. Third Brand.

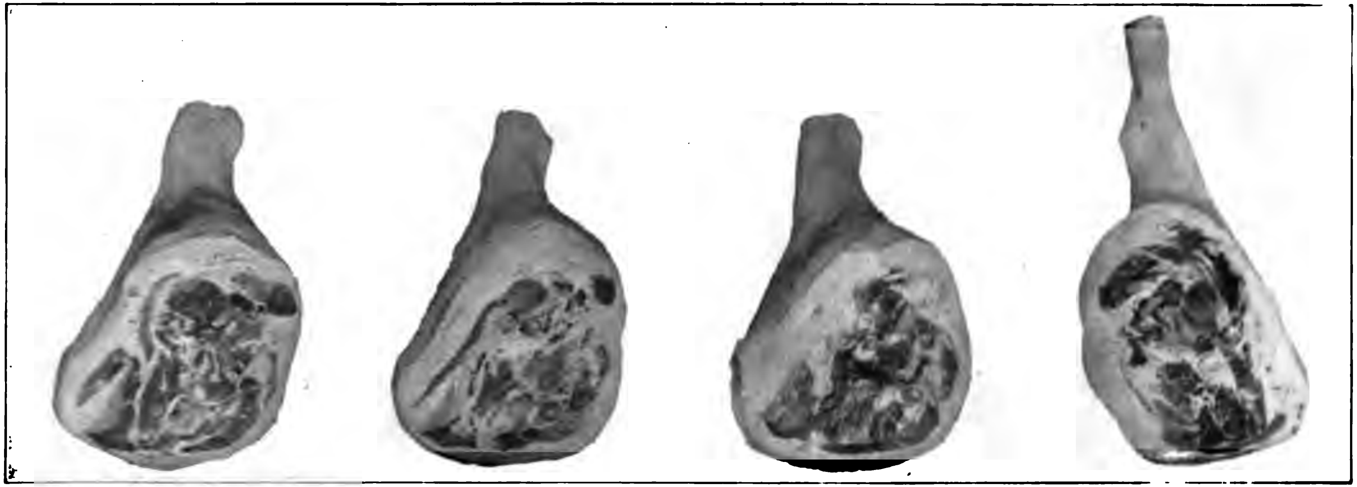

FIG 63 LONG-CUT HAMS.

Regular. Manchester. Stafford. Italian.

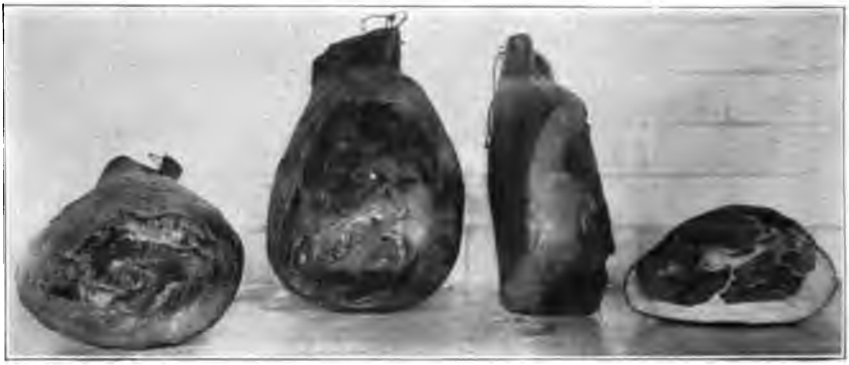

FIG. 64. SMOKED SHORT-CUT HAMS (FIRST BRAND).

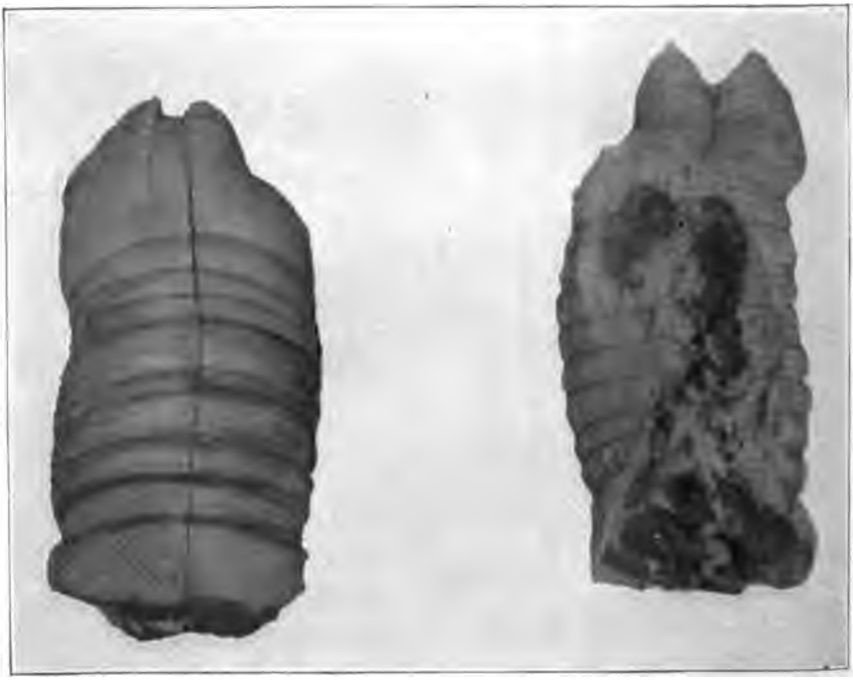

FIG. 65. BONELESS ROLLED HAMS.

Regular Long-Cut Hams are lean, long hams with only one-half to one and one-half inches of outside fat, and are "cut from the side by separating with a knife the hip-bone from the rump, properly rounded, foot unjointed at first joint below the hock".* They are not faced; and the butt end is left full, which gives it a flat, lean appearance. (Fig. 63.) Average weights are 10 to 20 pounds but usually above 14 pounds. This cut is made from good and choice bacon hogs. It is no longer extensively used but was formerly the leading export ham. "Yorkshire" or "York" Hams are cut slightly longer at the butt than regular, but are otherwise as described above. Both are packed as explained under "English Meats." "Smithfield" or Virginia Style Hams are long-cut and very lean, cured hard, spiced, and "aged" for several months before using. They weight 9 to 18 pounds.

"Stafford" Hams are cut about 2 inches shorter at the butt end than regular long-cut hams, hench-bone taken out exposing the socket joint, and foot cut off at the first joint below the hock. They are cut from good and choice bacon hogs and cured for English trade. This grade is made principally from 14 to 18-pound hams. See Fig. 63.

"Manchester" Hams are a very lean grade of long-cut hams, comparatively flat in shape, butted like "Staffords", and averaging 14 to 18 pounds. See Fig. 63.

"Italian" Hams are very thin, long hams, of 9 to 18 pounds average, and of common to good quality. The hench-bone is removed as from "Staffords", the leg left extra long, the butt trimmed like American or short-cut hams, the ham pressed flat, dry-salt cured, smoked dark and seasoned with pepper. See Fig. 63.

Numerous other styles or grades of hams which were formerly packed in large quantities, especially for export trade, are no longer made or used sufficiently to be regarded as standard products.

SIDES

This class includes various grades and cuts of *Short Ribs, Short Clears and "English" Bacon Sides.*

Short Rib Sides.—Regular Short Ribs are middles of hogs from which short cut hams and regular or New York shoulders have been taken off, with back-bone and tenderloin removed, hench-bone and breast-bone sawed or cut down smooth and even with face of side, feather of blade not removed and no incision made in the side. This is a regular Board of Trade cut and is quoted in provision reports simply as "Ribs". It is made from medium to heavy packing hogs, in averages from 25 to 80 pounds but principally from 45 to 65 pounds. On the Board of Trade regular ribs averaging not less than 30 nor more than 60 pounds are deliverable at contract price; those over 60 and not over 70 pounds average are deliverable at a discount of 20 cents per 100 pounds; those over 70 and not over 80 pounds are discounted 30 cents per 100 pounds. Regular ribs are mainly shipped south either as dry-salt or bacon meat. The manufacture of this cut is confined largely to the winter months. It is used less extensively in proportion to other cuts than formerly but is still the leading side cut, over one-half the stocks of sides generally consisting of short ribs. Many are afterward converted into other cuts, as extra ribs, extra clears, backs and bellies, as determined by current prices of the various cuts. About one-fifth of the number of heavy hogs packed are cut into short ribs.

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*Regulations Chicago Board of Trade.

Jobbing or Rough Short Ribs consist of short ribs with the back-bone left in, the hog being centre-split leaving equal parts of the back-bone on each side. They are sold at a discount of 2 percent under regular ribs and must average not less than 30 nor more than 50 pounds for Board of Trade delivery. See Fig. 66.

Hard Short Ribs are made the same as Jobbing Ribs except that the hog is split so as to leave the back-bone all on one side. The side containing the back-bone is known as the Hard Side or Hard Short Rib and the other as the Soft Side, the latter being the same as the Regular Short Rib. They usually weigh 50 to 70 pounds, are cut from heavy packing hogs and are sold principally in the South as dry-salt pork.

Extra Short Ribs or "Extra Ribs" are made from Short Ribs by removing the loin. They average 35 to 50 pounds. 20 to 30 percent of the stocks of sides usually consist of Extra Ribs. See Fig. 66.

Square Cut or "English" Short Ribs are the middles of hogs from which square shoulders and long-cut hams have been cut, thus making the side shorter than a regular rib, square-cut and with the feather of the blade-bone out. They are selected from the better grades of medium weight packing hogs, and average 20 to 30 pounds. They are cured in English Salt and handled like other "English" Meats.

Short Clear Sides. Regular Short Clears are made from regular short ribs by removing the ribs and cutting reasonably square at each end. They are graded and handled in the same manner as short ribs. Short Clears average 30 to 70 pounds and to grade regular must average not less than 35 pounds. Their use has declined to a large extent in recent years as compared with certain other cuts, and only 1 to 5 percent of the stocks of sides are of this kind. It is primarily a domestic cut but is exported to some

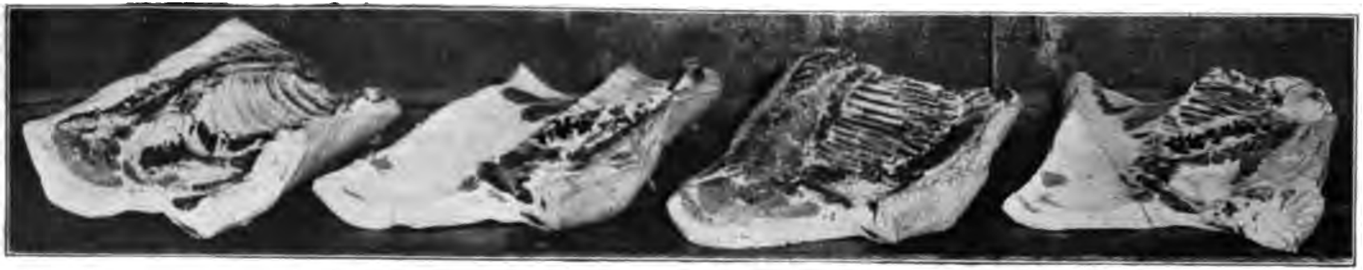

FIG. 66. SIDES.

Short Rib. Extra Short Rib. Short Clear. Extra Short Clear.

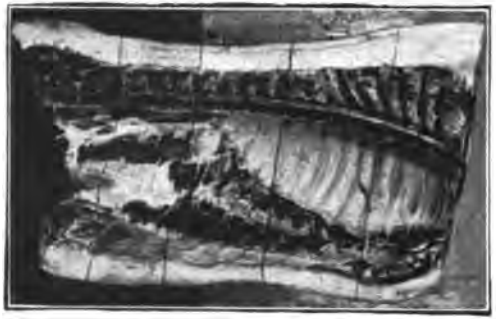

Fig. 66a. SHORT RIBS, CUT FOR MESS PORK.

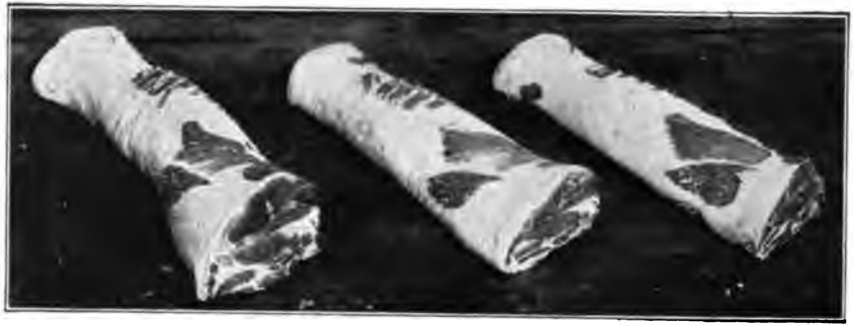

FIG. 66b. PORK LOINS.

Heavy. Medium. Light.

extent. See Fig. 66. Square-Cut Short Clears are the same as Square-Cut Short Ribs except the ribs are taken out.

Extra Short Clear Sides or "Extra Clears" are made the same as short clears except that the loin is also removed. They may be made from extra short ribs by cutting out the ribs. The pieces weigh 25 to 60 pounds, and must average not less than 30 nor more than 60 pounds to grade regular. 10 to 20 per cent of the stocks of sides are usually made up of this cut. See Fig. 66.

"English" Bacon Sides. These so-called sides or long middles include both the side and shoulder, and in one instance (Wiltshires) the ham is also included. They are cured and packed as described under "English Meats", and after arrival in Great Britain are usually made into "rolled sides", which are dried for English trade, but in Scotland are usually smoked. American packers have discontinued manufacturing several cuts not mentioned below which were formerly used quite extensively.

"Wiltshire" Sides consist of the side, ham and shoulder left together in one piece; the blade-bone is taken out, foot cut off, the shoulder trimmed the same as "Cumberlands", hip-bone taken out, not backstrapped, the belly trimmed smooth and even, and leg of the ham cut off below the hock joint. These sides average 40 to 70 pounds and are selected especially for thickness of lean meat with a light, even covering of fat from 1¼ to 2 inches thick, not exceeding 1¾ inches in the best grades. They are made exclusively from choice lean bacon hogs, and are the highest grade of English bacon sides. The use of "Wiltshires" has greatly declined in recent years. They are shipped principally to the south of England. See Fig. 67.

"Cumberland" Sides "have the end from which the ham is taken cut square; the leg cut off below the knee joint; the shoulder ribs, neck-bone, back-bone and blood vein taken out; breast-bone sawed or cut down smooth and even with the face of the side; and should not be back-strapped or flanked".* They are made from good and choice bacon hogs and average 20 to 60 pounds, but the bulk run 25 to 40 pounds. This is by far the leading export side cut, and being made in various grades and averages is suitable for converting into other English side cuts, such as "Yorkshires", "Birminghams", "Staffords" and others which are no longer generally made in this country. See Fig. 67.

Long Rib Sides are made the same as Cumberlands except the shoulder bones are taken out and the leg cut off close to the breast. The average weight is 18 to 25 pounds. They are made from common to good bacon hogs, and shipped to Liverpool for distribution to Ireland and Wales.

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*Regulations Chicago Board of Trade.

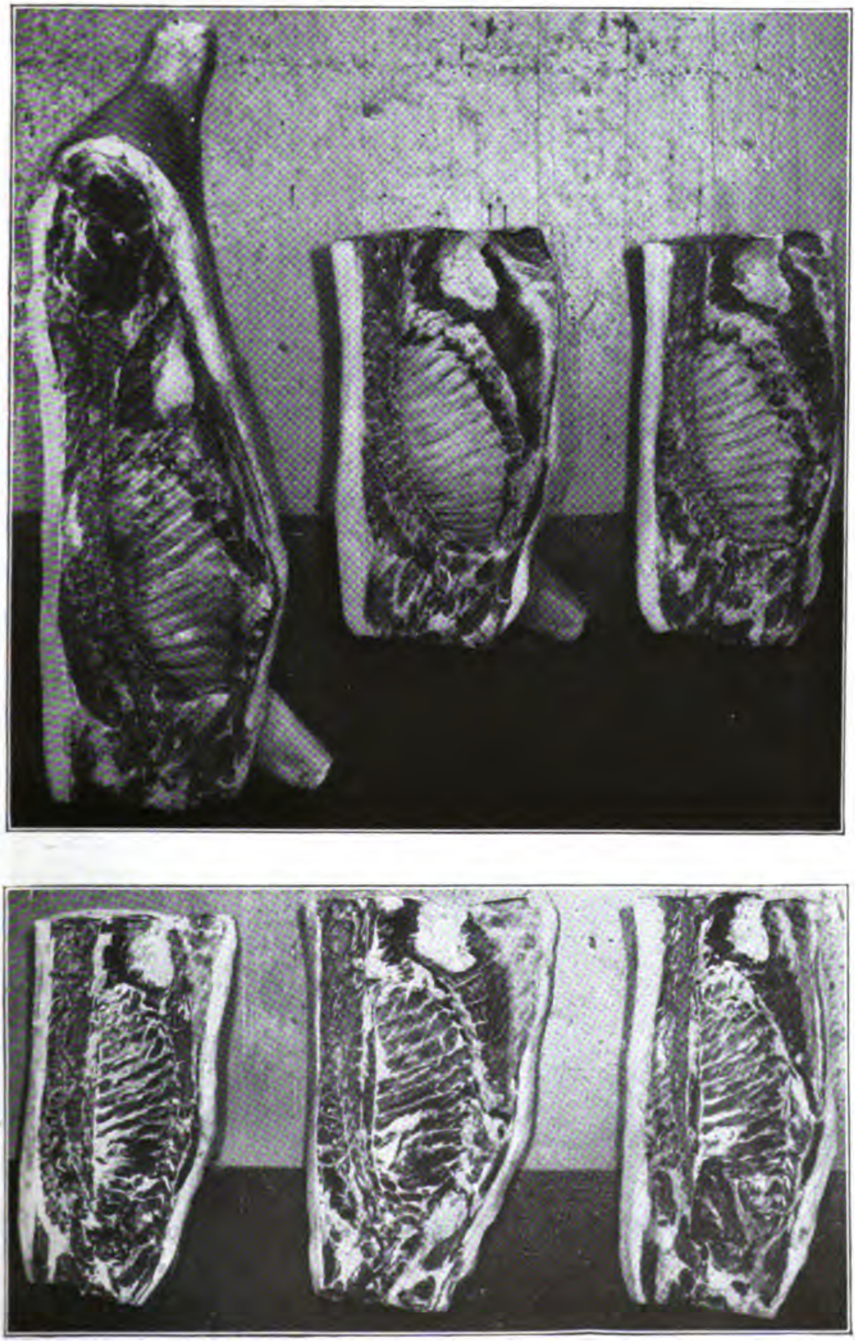

FIG. 67. LONG SIDES.

Wiltshire **Long Clear**	**Cumberland** **Yorkshire**	**Dublin** **Staffordshire**

Long Clear Sides are cut the same as long ribs and in addition have the ribs taken out. For English trade, they are made from good bacon hogs weighing 120 to 160 pounds dressed, and the sides weigh 18 to 26 pounds. See Fig. 67. For regular Board of Trade delivery they must average not less than 45 pounds. The latter are used in domestic trade and Continental Europe, and are made from the heaviest bacon hogs and from comparatively lean butcher hogs. This cut is used to some extent both in export and domestic trade, but much less than formerly. Extra long clears are made like long clears except that the loin is also removed. They are seldom used.

"Dublin" Middles are thin lean sides cut like "Cumberlands" and in addition the leg cut off close to the breast. They are made from light, common bacon hogs and pigs. The sides weigh 12 to 20 pounds. See Fig. 67.

BELLIES

The grades of this cut are *Dry-Salt, Sweet-Pickle, Breakfast-Bacon* and *"English" Bellies.*

Dry-Salt Bellies are made from short rib sides of mixed packing hogs by cutting off the back. For delivery on the Board of Trade they must be "well cut and trimmed; no bellies that are coarse, bruised, soft or unsound shall be accepted".* However, they are not as closely trimmed as sweet-pickle bellies. They are made in averages from 10 to 45 pounds. About two-thirds of the stocks of bellies at Chicago usually consist of this grade. They are quoted as Dry-Salt Rib and Dry-Salt Clear Bellies, the latter having the ribs removed and being made usually from bellies weighing less than 25 pounds. When smoked they are known as "Bacon Meats". See Fig. 68.

Sweet-Pickle Bellies are made from butcher, bacon and good packing hogs, being "well cut and trimmed, to average, in lots, not to exceed 14 pounds".* The edges are squared and trimmed more closely than Dry-Salt bellies. They are made in 6 to 14 pound averages, packed the same as sweet-pickled hams and sold either as sweet-pickled or smoked meats. About one-third of the supply of bellies are sweet-pickled. They are quoted both as Rib and Clear Bellies, the latter having the ribs removed. See Fig. 68.

Breakfast-Bacon Bellies are clear bellies cut from bacon or light butcher hogs and selected with reference to firmness, color, proportions of fat and lean, smooth skin and general quality. They are trimmed still more closely than the regular sweet-pickled bellies. Selected bellies of this class weighing 4 to 10 pounds are

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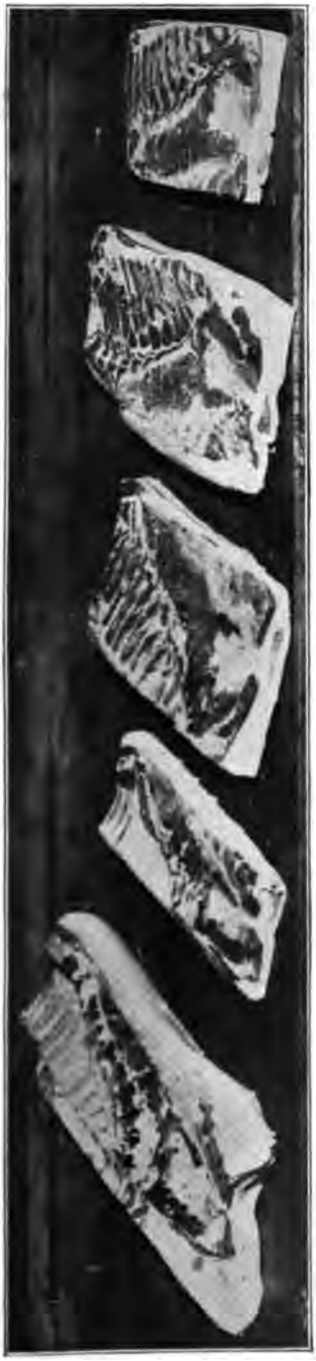
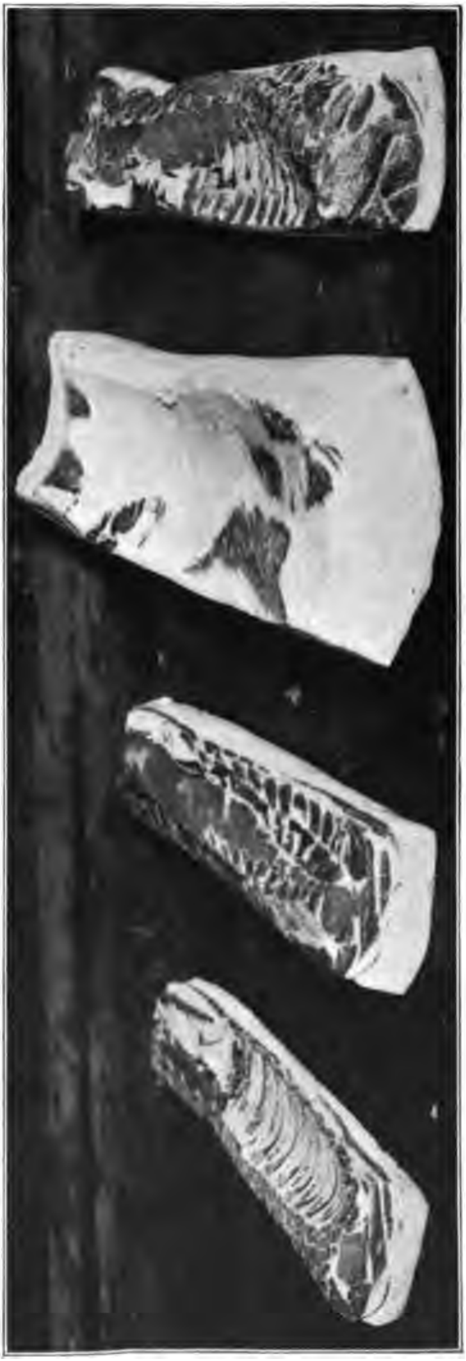
*Regulations Chicago Board of Trade.



Dry-Salt Rib. Sweet-Pickle Rib. English Clear. Sweet-Pickle Clear. Fancy Clear.

FIG. 68 BELLIES.



English Rib. English Clear. Short Fat Back. Sweet-Pickle Clear.

FIG. 69. BACKS.

known as Fancy or Special Breakfast Bacon Bellies and are made into the best brands of sugar-cured breakfast-bacon. They are carefully selected, dry-cured in air-tight boxes and smoked lightly. The second brand includes bellies that are too fat for fancy bacon, or which lack the necessary firmness of flesh and thin smooth skin. They weigh 4 to 16 pounds. The third brand is made from bellies weighing 6 to 18 pounds that are either slightly bruised, or too deficient in general quality for the second brand. See Figs. 68, 70.

"English" Bellies are clear bellies weighing 10 to 20 pounds, cut from choice heavy bacon hogs and light butcher barrows, and selected for firmness and a large proportion of lean. They are cut square on all edges and packed as explained under "English Meats". See Fig. 68.

BACKS

The grades of backs are *Short Rib, Short Clear, Short Fat* and *Long Fat Backs.*

Short Rib Backs are made from short rib sides by cutting off the belly; they therefore contain the loin, back fat and back-ribs but not the back-bone nor tenderloin. It is a dry-salt cut, weighing 25 to 45 pounds and is not commonly made. Hard Backs are made from hard rib sides, thus containing the back-bone. "English" Rib Backs are made from Square Short Ribs, and average 12 to 20 pounds. See Fig. 69.

Short Clear Backs are "made from the sides of smooth hogs from which the bellies have been cut, back-bone and ribs taken out and the lean left on, tail-bone sawed off even with the face of

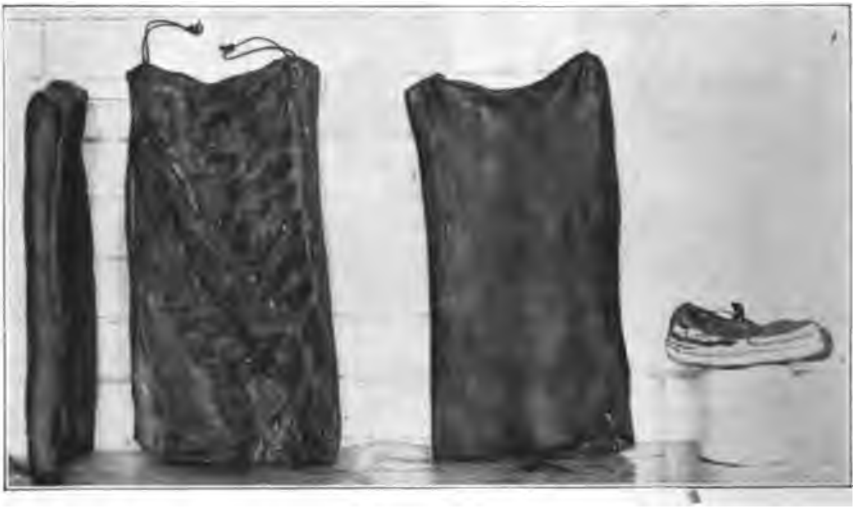


FIG. 70. SMOKED BREAKFAST-BACON BELLIES (FIRST BRAND).

the meat, and trimmed smooth and square on all the edges".* They are cut from medium and heavy packing hogs, dry-salted and sold largely in continental Europe. The weights run from 16 to 40 pounds. "English" Short Clear Backs are lighter than regulars, averaging 10 to 20 pounds, and are shorter at the butt end, being cut off in front of the hip-bone. They are packed like other English meats. See Fig. 69. Pickled Clear Backs are short clear backs of light weight and lean quality. They weigh 6 to 10 pounds and are sweet-pickled, smoked, and sold as "Loin Back Bacon" or "Breakfast Bacon Backs". See Fig. 69.

Short Fat Backs are "made from the sides of heavy, well-fatted hogs from which the bellies have been cut, back-bone and ribs taken out and all the lean taken off, to be trimmed smoothly and properly squared on all the edges".* This is one of the leading back cuts. It is made from packing and loin hogs when cutting pork loins, and is usually quoted as a dry-salt cut in 8 to 20 pound averages. See Fig. 69.

Export Short Fat Backs have the blade-bone taken out, are more closely trimmed and squared than domestic backs and are made principally in heavy averages, 16 to 40 pounds. Paprika Fat Backs are thin, light fat backs, weighing 4 to 8 pounds. They are dry-salted and seasoned with paprika.

Long Fat Backs consist of "the upper half of the side cut thru the centre of the ribs from the ham to and including the shoulder, with the loin and blade-bone taken out, trimmed smoothly and squared on all edges".* It is a dry-salt cut, not as commonly made as formerly and used only for export trade. See Fig. 61.

LOINS

Loins, consisting of the back with the fat trimmed off, are sold either as *Regular Pork Loins* or as *Loin Rolls.*

Pork Loins are made from sides of loin hogs, with the belly and back-fat cut off; they contain the back-bone, back-ribs and tenderloin, and have but a small amount of fat (one-fourth to one-half inch) on the outside. The loin is the leading fresh pork cut, and as it is retailed entirely in the form of chops and roasts, it must have reasonably good shape, bright color, firm, fine-grained flesh and good quality of bone. Loins are made principally from butcher hogs, but also to some extent from good packing and heavy bacon hogs. The weights of regular pork loins are 8 to 18 pounds and the price usually varies inversely as the weight, except occasional loins that are graded No. 2 on account of dark color or coarseness of flesh and bones. 14 pounds is the heaviest average generally used for fresh trade, and a few are made as light as 4 to 6 pounds. See Fig. 66b. Extra or Long Pork Loins include, in addition to the regular loin, the top or lean butt of the shoulder, but this cut is seldom made.

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*Regulations Chicago Board of Trade.

Tenderloins consist of short round muscles lying underneath and on each side of the back-bone; they are attached to the "slip-bone" and extend from the loin butt almost to the last rib. They weigh one-fourth to one pound each, but those weighing three-fourths pound or over are most extensively used. They are cut from hogs that are too heavy and rough to yield regular pork loins, and from which short ribs, mess pork and boneless loins are made. The tenderloin is sold only as a fresh cut.

Loin Rolls are made from heavy loins (15 to 22 pounds) by boning them completely, tying three boneless loins together lengthwise in the form of a roll, curing in sweet pickle, smoking and boiling. Light No. 2 loins are also packed in this manner in smaller quantities. Loin rolls are used by restaurants and delicatessen shops.

SHOULDERS

The standard grades are *Rough, Regular, Picnic, New York Cut, Skinned, Square, New Orleans Cut* and *Boneless Rolled Shoulders.*

Rough Shoulders are untrimmed shoulders as cut from the hog, separated from the side between the first and second ribs and with the jowl cut off square. They are quoted as fresh meats but are not extensively used. See Fig. 72.

Regular Shoulders are "cut as close as possible to the back part of the forearm joint without exposing the knuckle, (leaving 2 ribs on the shoulder), butted off square on top, the neck-bone and short ribs taken out, neck squared off, blood vein lifted and cut out, breast flap cut off and foot cut off on or above the knee joint".* They are made principally from hogs that are too heavy and rough for New York style shoulders, and at times when the supply of picnics exceeds the demand. About 15 percent of the stocks of shoulders generally consist of Regulars, of which about one-third are handled as dry-salt shoulders, averaging 15 to 20 pounds, and about two-thirds as sweet-pickled shoulders averaging 12 to 16 pounds. Sausage Shoulders are regular-cut shoulders which are unsuitable for dry-salt or sweet-pickle because of being trimmed to remove bruises, cut from "shoulder-stuck" hogs, or otherwise deficient, and are used for the purpose which their name indicates. Bladed Shoulders are cut the same as Regulars except the shoulder-blade is taken out and the corners rounded. Comparatively few are cut in this manner.

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*Regulations Chicago Board of Trade.

Picnics or *Calas* (formerly termed California hams) are cut 2½ ribs wide, trimmed and packed as follows: "Shank cut off above the knee joint, trimmed as full on the face (lean surface) as possible, butt taken off to the edge of the blade, well rounded at the butt in the shape of a ham, breast flap taken off, and trimmed close and smooth, reasonably uniform in size, and to average, in lots, not to exceed 12 pounds. 300 pounds block (green) weight shall be packed in each tierce. Pickle the same as used for hams".* They are cut from good packing and butcher hogs, averaging 4 to 14 pounds, but principally 8 to 12 pounds, and are sold almost entirely as sweet-pickled, smoked and boiled meats. The lighter averages (4 to 8 pounds) are sometimes termed Boston Shoulders, and were formerly butted shorter than Calas and only slightly rounded; but Chicago and other western packers now trim them like Calas and designate both as Picnics. About 85 percent of the wholesale supply of shoulders are made into Picnics. See Fig. 74. Skinned Picnics are made from the fatter grades of Picnics by removing the skin and trimming the fat off within one-half inch of the lean. They average 6 to 10 pounds, and are sold largely as Boiled Meats.

New York Cut Shoulders are cut two ribs wide, butted one inch from blade-bone, trimmed smooth, neck and breast flap cut off, and shank cut off between knee and brisket. 8 to 14-pound grades are made for domestic trade and the bulk weigh 10 to 12 pounds, but heavier weights up to 18 pounds, are exported. They are made principally from butcher and packer hogs, and are quoted as fresh, smoked and sweet-pickled meats. They are not as extensively used as formerly in proportion to other cuts. See Fig. 72.

Skinned Shoulders are cut similar to New York Cut Shoulders and in addition the skin is taken off down to the shank and the fat trimmed off close to the lean. They weigh 6 to 16 pounds, and are sold fresh, sweet-pickled and smoked. They are the leading fresh shoulder cut used in city retail trade. See Fig. 72. Skinned shoulders with the shank cut off close to the breast are termed "Chicago Shoulders", or "Skinned Shoulders, hock off".

Square or 3-Rib Shoulders are cut three ribs wide, squared on all sides, neck-bones out, breast flap off, foot cut off at the knee joint, butted just above blade-bone, and so trimmed as to expose the lean as much as possible. This is the leading "English"

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*Regulations Chicago Board of Trade.

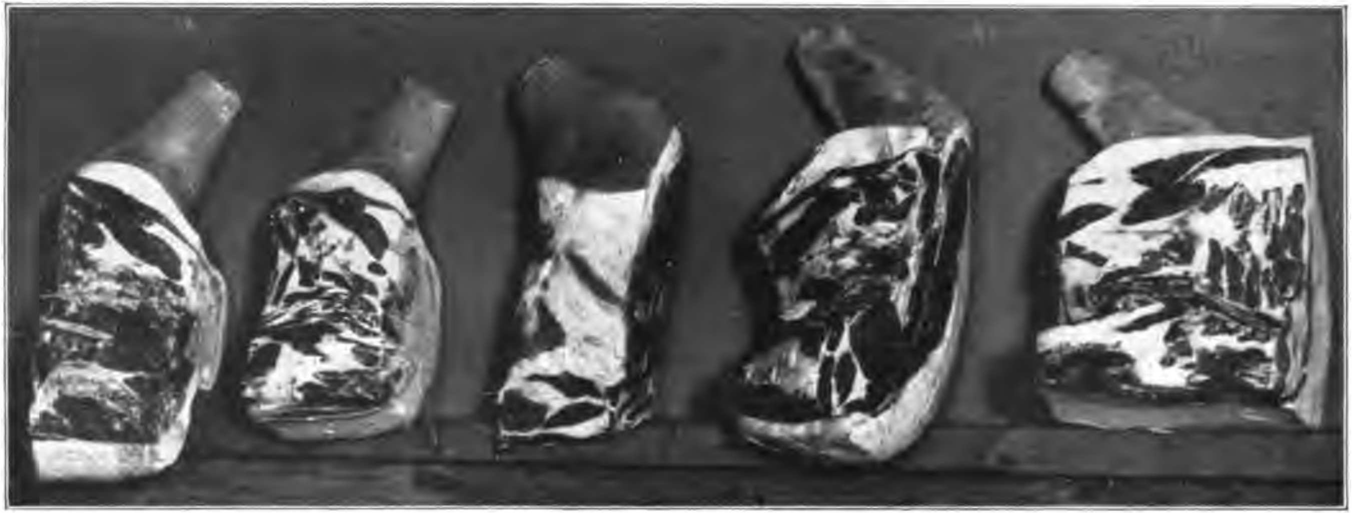

FIG. 72 SHOULDERS.

Rough. New York. Skinned. New Orleans. Square.

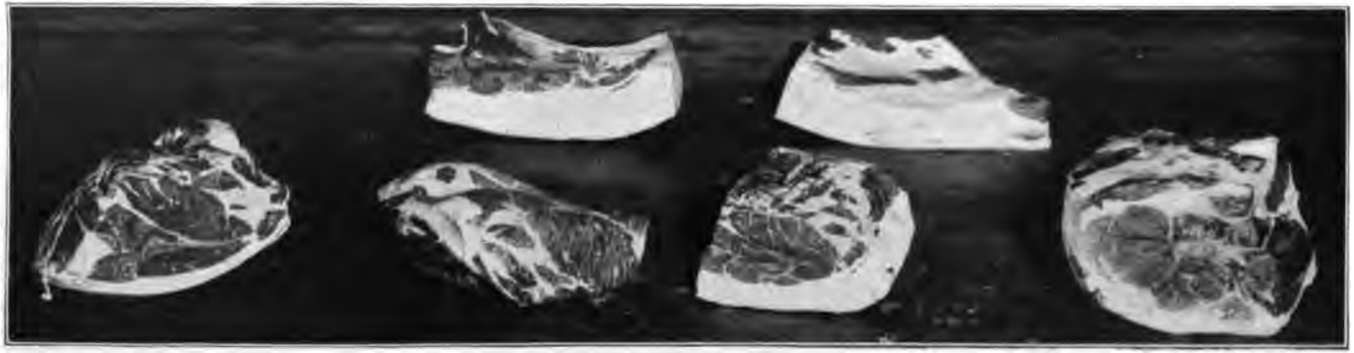

FIG. 73. BUTTS AND PLATES.

Boston Butt. Regular Plate. Boneless Butt. Clear Plate. New York Butt. Picnic Butt shoulder cut, and is made in averages from 10 to 20 pounds. See Fig. 72.

New Orleans Cut Shoulders are made 1½ ribs wide, smooth and rounded on neck end, part of shoulder butt left on and neck-bone out. They are cut principally in 12 to 14 pound averages, but are also made from 10 to 16 pounds, from shoulders that are too rough and fat to make New York Cut or Picnic Shoulders. This is a dry-salt cut. See Fig. 72.

Boneless Rolled Picnics are made from heavy picnics by lifting the skin, removing the surplus fat and the bone, pressing or rolling and tying with cord in the form of a roll in the same manner as rolled hams. They are also made from skinned picnics. Boneless rolled shoulders are made similarly from regular shoulders. They are sold as boiled meats.

BUTTS AND PLATES

Butts are cut from the end or top of the shoulder and from the jowl. Plates are made from shoulder butts. The various grades of these cuts are *Boston Style, Milwaukee Style, Boneless, Buffalo Style, New York Style, Picnic, Dry-Salt* and *Square-Cut Butts; Regular Plates, Clear Plates* and *Back Plates.*

Boston Style Butts are the ends or top pieces cut from heavy shoulders when making picnics; the neck-bone, ribs and surplus fat being removed and the piece trimmed smooth. They include the end of the shoulder blade. Average weights are 3 to 7 pounds. They are principally barreled and exported to Germany, Denmark and other European countries, but are also sold fresh for domestic retail trade. See Fig. 73.

Milwaukee Style Butts are the same as Boston butts with the neck-bone and rib left on.

Boneless Butts or *Lean Butts* (also termed Cala Butts) consist of the lean, boneless portion of Boston butts between the blade-bone and neck-bone. When sweet-pickled and smoked like hams this cut is known as a Cottage Style butt. See Fig. 73.

Buffalo Style Butts are cut the same as boneless butts except that the neck-bone is left in. They are used fresh.

New York Style Butts are shoulder butts cut from picnics of the thinner and lighter grades. They contain the neck-bone, fat and lean, and are mainly plain-pickled. See Fig. 73.

Picnic Butts are picnics from which the surplus fat and the skin are removed and the shank cut off close to the breast. They are not trimmed as closely as regular picnics. See Fig. 73.

Dry-Salt Butts are made from the jowl (lower part of the neck and cheek), with the edges trimmed smooth and the piece

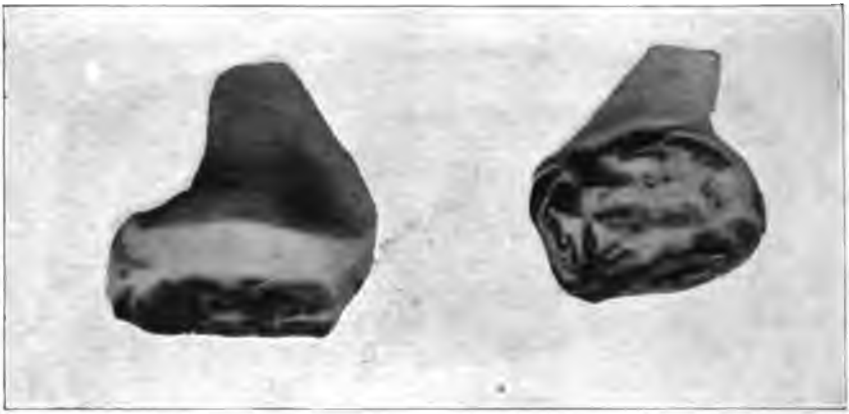

FIG. 74. PICNICS.

Heavy. Light.

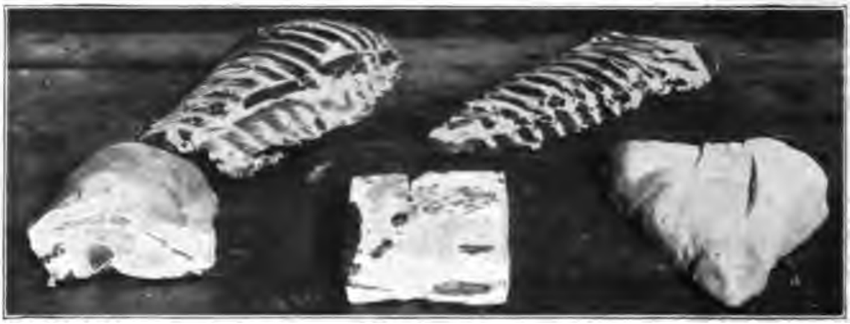

FIG. 75. SPARE RIBS (FULL SHEET). SPARE RIBS (HALF SHEET). DRY-SALT BUTT (JOWL). SQUARE-CUT BUTT. VIRGINIA-STYLE JOWL.

pounded flat. They weigh 3 to 5 pounds and are usually packed as their name indicates but are sometimes barreled. Virginia-Style jowls are made from the smaller end of the lower jaw including the teeth, and are made both tongue in and tongue out. They are sugar-cured and smoked, but are not extensively made. See Fig. 75.

Square-Cut Butts are also made from the jowl but are more closely trimmed and squared. They average 2 to 4 pounds and are dry-salted or barreled. See Fig. 75.

Regular Plates are made from shoulder butts by removing a boneless butt, thus making a fat piece with a facing of lean, containing the end of the blade-bone, and weighing 6 to 12 pounds. They are packed either as dry-salt or barreled pork. When made with the blade-bone out they are known as Antwerp Backs. See Fig. 73.

Clear Plates are made from shoulder butts by removing a Boston butt, and are a clear fat cut, weighing 4 to 8 pounds. They are generally dry-salted but are barreled to some extent. See Fig. 73.

Back Plates are made from long fat backs, cut into keystone-shaped pieces weighing 3½ to 10 pounds. They are both barreled and dry-salted.

MISCELLANEOUS

The cuts described under this head consist principally of barreled pork and other products made from sides and shoulders of packing hogs. They may be grouped as follows: *Mess Pork, Belly Pork, Back Pork, Shoulder Pork, Spareribs,* and *Trimmings.*

Mess Pork. Regular Mess Pork is "made from sides of well fatted hogs, split thru or one side of the back-bone, and equal proportions on both sides, cut into strips of reasonably uniform width, properly flanked and not backstrapped".* See Fig. 66a. The regular proportion of flank and shoulder cuts must be included. The strips average about six inches in width, and not over sixteen pieces may be packed in a barrel for regular delivery. Mess Pork is made from rough and heavy packing hogs and occasionally from heavy loin hogs. During the early years of the packing industry about one-third of the wholesale pork product consisted of mess pork, but it has been largely replaced by other cuts during recent years, and is now only two or three percent of the supply. Approximately one-half of the Barreled Pork supply is Mess Pork. On the Board of Trade it is quoted simply as "Pork". Mess pork packed between October 1 of one year and September 30 of the succeeding year is "new pork" until January 1 of the following year, and is thereafter termed "old pork". Mess pork made during December, January and February must have been packed at least ten days before delivery, and that delivered during the period from March to November, inclusive, must have been packed at least thirty days before delivery to grade regular. It is barreled and shipped principally to the southern states, northern lumber camps and South America. Short-cut Mess Pork is described in connection with Back Pork.

Light Mess Pork is "made from the sides of reasonably well fatted hogs; and in all other respects to be cut, selected and packed the same as mess pork, except that as many as 22 pieces may be put into each barrel".† It is made principally from medium packing hogs.

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*Regulations Chicago Board of Trade. "Backstrapping" refers to trimming a strip of fat from the edge of the side, above the back-bone.

†Regulations Chicago Board of Trade.

Prime Mess Pork is made from the shoulder and side, containing the back-bone and ribs, cut into square pieces of about 4 pounds each. The shank is cut off close to the breast. In making this cut the side is split lengthwise, the back cut into about six pieces and the belly into four. It is made from light packing hogs.

Extra Clear Pork is "made from the sides of extra heavy, well-fatted hogs, the back-bone and ribs to be taken out, (the same as short clear sides) the number of pieces in each barrel not to exceed 14, and in all other respects to be cut, selected and packed in the same manner as mess pork".* This cut is not extensively made.

Clear Pork is "made from the sides of extra heavy, well-fatted hogs, the back-bone and half the ribs next the back-bone to be taken out, the number of pieces in each barrel not to exceed 14, and in all other respects to be cut, selected and packed in the same manner as mess pork".* It is no longer in general use.

Loin Clear Pork is "made from the sides of medium-weight packing hogs, the loin, back-bone and back ribs being removed and belly ribs left in". It consists of extra short ribs cut into strips, and is also known as Long-Cut Clear Pork. The pieces average five inches in width. It is barreled like mess pork and sold especially to New England trade.

Belly Pork. Regular Belly Pork consists of heavy, fat rib bellies cut into 5-inch widths and packed as plain-pickled pork in barrels of 50 to 60 pieces. This pork is made from the same grade of bellies as Dry-Salt Rib Bellies.

Brisket Pork Rib is made by cutting a 5-inch strip from the brisket end of heavy rib bellies (14 to 20 pounds average) and packing like other barreled pork. The pieces average about 4 pounds each. This cut is made only when it is desired to reduce the weight of heavy bellies. Clear Brisket Pork is made in the same manner as the above except the pieces are cut from clear bellies. Fancy Clear Pork is a strip cut from the brisket end of fancy breakfast bacon bellies, averaging 1 to 1½ pounds per piece. It is either barreled or sugar cured and smoked.

Lean Belly Pork consists of lean clear bellies, 13 to 15 pounds average, cut into three pieces each and barreled in plain pickle.

Back Pork. Regular Back Pork (Short Cut Mess, or Family Back Pork) is "made from the backs of well-fatted hogs, after bellies have been taken off, cut into pieces of about 6 pounds each, and in all other respects to be cut, selected and packed in the same manner as mess pork".* This cut contains the loin, back-bone and back ribs, with tenderloin out, and the pieces are cut 6 inches wide, averaging 4 to 6 pounds.

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*Regulations Chicago Board of Trade.

Clear Back Pork is "made from the backs of heavy, well-fatted hogs, after bellies have been taken off, and back-bone and ribs taken out, cut into pieces of about 6 pounds each, and in all other respects to be packed in the same manner as mess pork".* In other words, it consists of Short Clear Backs cut into strips about 6 inches wide, and is the same as Regular Back Pork with the rib removed. It is sometimes called Loin Clear Pork. The pieces average 2 to 7 pounds.

Fat Back Pork or Short Cut Clear Pork is made from short fat backs by cutting them into 5-inch strips. The pieces average from 2 to 7 pounds and are packed like mess pork. Speck is made from fat backs, cut into strips, cured in plain pickle and seasoned with pepper.

Ham Butt Pork (Loin End or Rump Pork) consists of triangular pieces cut from the ham end of short clear backs or sides and includes a portion of the tail-bone. It is made when cutting short-cut hams and "English" sides, or when it is desired to reduce the weight of heavy sides or backs. It is packed in barrels, the pieces averaging 3 to 4 pounds.

Shoulder Pork consists of the following products made from shoulders and butts:

Extra Prime Pork is "made from heavy untrimmed shoulders cut into 3 pieces; the leg to be cut off close to the breast, and in all other respects to be cut, selected and packed in the same manner as mess pork".* The pieces average about 4 pounds. This and the preceding cut are not used as extensively as formerly.

Boston Style Butt Pork is made from Boston Style Butts averaging 4 to 7 pounds, packed in plain pickle.

Bean Pork or Clear Butt Pork is made from the jowl or fat cheek of the hog, cut square, trimmed smooth and averaging 3 to 4 pounds, packed in plain pickle.

Spareribs consist of the ribs trimmed from the carcass or side with as little lean as possible. They are termed "full-sheet", "half-sheet" and "back-bone" spareribs according as they are cut from full sides, bellies or backs respectively. They are essentially a fresh pork product and are sold in retail markets especially in fall and winter, for which purpose "half-sheet" ribs are principally used. Spareribs are also quoted as sweet-pickled, smoked and dry-salt meats. They are packed in limited amounts in sweet pickle at times when the demand for fresh spareribs is dull; dry-salt spareribs are taken from dry-salt sides and bellies when making them into clear cuts after curing. Both pickled and dry-salt spareribs are smoked to a limited extent. See Fig. 75.

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*Regulations Chicago Board of Trade.

Various other meats are handled and quoted similarly to spareribs. Hocks consist of the shank or foreleg cut from the shoulder, including the portion between the breast and knee. They are sold either fresh or barreled. Back-bones, neck-bones and blade-bones are to some extent sold fresh like spareribs, but are usually tanked.

Trimmings are of two grades: Special Lean, or "A" grade, and Regular or "B" grade. Special Lean or Berliner Trimmings consist of the larger pieces of meat with fat cut off and are used especially for making Berliner sausage. The regular grade is made up of small pieces of fat and lean, miscellaneous in shape and quality, and contains about 40 to 50 percent fat. Both grades are almost entirely utilized in sausage manufacture.

LARD

From one-tenth to one-third of the hog carcass is made into lard in large packing-houses, the proportion varying with the relative price of lard and grade of hogs. The standard grades are *Kettle-Rendered Leaf, Kettle-Rendered, Neutral, Prime Steam, Refined* and *Compound Lard*. They differ as to the kinds of fats they contain, methods of rendering, color, flavor and grain.

KETTLE-RENDERED LEAF LARD

This consists of leaf fat only, rendered at about 248° F. in open-jacketed kettles, without the addition of water and without subsequent refining. It is the whitest in color and finest in grain and flavor of all grades of lard. Kettle-rendered lard is distinguished from other kinds by the wavy or fluffy appearance of the surface, known as a "crinkly top", and this is characteristic especially of leaf lard. It is sold principally in pails of various sizes for retail trade. Most packing firms do not render pure leaf lard but make the leaf into Neutral. Raw leaf fat is also sold fresh to butterine manufacturers and is used to some extent by retail trade.

KETTLE-RENDERED LARD

This grade is made from back fat with or without a proportion of leaf or "leaf scraped" lard, (seldom exceeding 20 percent) and not over 5 percent of lard stearin.* Ham-facing fat and fat trimmings are also used at times. It is rendered in either open or closed kettles but not under pressure nor in contact with live steam. The open-kettle product is sometimes branded "Country Style Lard". This is the highest grade of lard made in most packing houses, and is excelled in whiteness, grain and crinkly appearance of the surface only by genuine leaf lard. Kettle-rendered lard more readily becomes rancid than refined lard, hence flavor and keeping qualities are especially important in this grade. It is made in comparatively limited quanities, and is packed in 3 to 50 pound pails for retail trade, 50 to 80 pound tubs, and tierces.

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*Lard stearin is the residue left after pressing the oil from lard. Having a high melting point, it is usually mixed with lard during the summer months or when shipping to a warm climate.

NEUTRAL LARD

Neutral Lard is made from leaf or back fat melted in water-jacketed open kettles at about 128° F., at which temperature the fat partially liquifies without cooking. No. 1 Neutral is made from leaf fat only. When drawn off and strained the melted fat is tasteless, free of acids and impurities, smooth-grained and remains unchanged in odor and color. It is sold in tierces and is used principally in the manufacture of butterine or oleomargarine. This grade of lard is largely exported, Rotterdam being the principal foreign market for it. No. 2 Neutral lard is made from back fat melted in the same manner as the No. 1 grade. It is not as white in color nor as fine in grain but is used for the same same purposes when No. 1 Neutral is high in price.

PRIME STEAM LARD

Prime Steam Lard is made from fat trimmings (ham, shoulder, belly, jowl and head fats), internal or "killing fats" and other fat parts, sometimes including entire fat backs, jowls, etc., rendered in closed tanks under about 40 pounds direct steam pressure (240° F.) without refining, stirring or bleaching. It is darker-colored and coarser-grained than other grades of lard, and is the form in which nog fats can be most economically stored and shipped. It is stored in tanks and tierces, and shipped in tierces or tank cars. Prime steam lard is refined before using, being converted into other grades of lard or used in Compound. Nine-tenths or more of the lard made at Chicago is of this grade. For delivery on the Board of Trade, "it must have proper color, flavor and soundness for keeping, and no material which has been salted must be included. Prime steam lard of superior quality as to color, flavor and body may be inspected and labeled as 'Prime Steam Lard, choice quality'". When rendered from cured fats such as sweet-pickled ham and shoulder fat, or for other reasons defective in color, flavor or grain, it is graded as No. 2 Steam Lard, being darker in color and coarser in grain than the regular grade.

REFINED LARD

Refined Lard is made from Prime Steam Lard by a bleaching and stirring process, consisting of rapid agitation with fuller's earth at about 180° F., followed by pressing through filter cloths and chilling. A proportion of lard stearin, not exceeding 5 percent, may also be added. If oleo stearin, tallow or more than 5 percent of lard stearin be added, the product may not be labeled "Pure Lard", and the added fats must be named on the package. It is sold in tierces, barrels, cans and pails, and is packed in 28 and 56-pound boxes for export.

COMPOUND LARD

Compound Lard or Lard Compound is a mixture of lard, stearin or other animal fat, and vegetable oil (usually cottonseed oil). All the ingredients must be named on the label, and the proportion of lard must equal or exceed that of any other one of the ingredients.

Note.—Compounds, or lard substitutes, differ from compound lard in that they contain little or no lard but are composed of oleo stearin, lard stearin and tallow mixed with refined cottonseed oil. The proportion of cottonseed oil is usually 80 to 85 percent. The amount of this product manufactured is approximately equal to that of lard. It is packed in the same kinds of receptacles as refined lard.

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BULLETIN No. 147—ABSTRACT

MARKET CLASSES AND GRADES OF MEAT

By LOUIS D. HALL

URBANA, ILLINOIS, JULY, 1910

OCT 15 1910
Museum of Comparative Zoology

MARKET CLASSES AND GRADES OF MEAT*

BY L. D. HALL, ASSISTANT CHIEF IN ANIMAL HUSBANDRY

Bulletin No. 147 describes and illustrates the standard classes and grades of beef, veal, mutton and pork recognized in the wholesale trade at Chicago, and defines various technical terms that are commonly used in wholesale quotations of meat products. It is a bulletin of some 150 pages and includes 75 engravings from original photographs of representative carcasses and cuts of meat. The cost of the publication renders it impossible to send it to all addresses on the mailing list at this time. The notes, outlines and illustrations contained in this abstract represent the nature and scope of the work and will enable the reader to determine whether he desires a copy of the bulletin.

INTRODUCTION

The most intelligent production of animals for slaughter involves a knowledge of the standard requirements of the meat market. Breeders, feeders or investigators who consider only the cost of production and the market value of the live animal, ignoring the demands of the meat trade, overlook one of the most important factors that affect the live stock market and may thus fail to follow the most rational lines of improvement in breeding and feeding.

Live stock producers, however, have exceedingly limited opportunities for becoming familiar with this subject. The rapid development of transportation, refrigeration, slaughtering and packing facilities has led to the present system of large markets separated by distances which make them practically inaccessible to a large majority of stockmen. Further, since animals are sold by live weight the shipper feels concerned with their value on foot rather than their dressed yield. Finally, definite classifications are lacking in some branches of the meat trade, and the classifications in use are often complicated by variations in market conditions. The trade has become so vast and complex that it is very difficult—and has become increasingly difficult with each succeeding year—for one not engaged in the meat business to secure a definite knowledge of its various branches. The present tendency toward a more highly centralized organization of the retail meat business in some localities increases still further its inaccessibility to the live stock producer. As a result of these conditions meat dealers and consumers are far more familiar with the subject than meat producers. This work, therefore, is intended primarily to be of value to breeders and feeders who do not have opportunities to secure the information directly. With an understanding of meat trade requirements it is possible for a stockman to judge the carcass yield and quality of his animals as intelligently as buyers at the stock-yards; because his knowledge of the feeds used, length of feeding period and gains made, are as essential in making such estimates as the apparent form, condition and quality of the fat animal, upon which points the buyer must chiefly rely.

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*The complete edition of the bulletin, of which this is a condensed outline, will be sent as long as available, upon request. Address Director, Agricultural Experiment Station, Urbana, Illinois.

The descriptions presented are based on data secured by the writer in a personal investigation at wholesale meat markets at the Union Stock Yards, Chicago, which are the largest establishments of their kind in the world; also at prominent wholesale and retail markets in Chicago and other cities which are supplied from the large houses at the Union Stock Yards. The engravings are from photographs taken under the writer's direction at the markets and at this Experiment Station. The officials and salesmen of the large packing houses and the retail dealers, jobbers, and other authorities who were consulted gave the most willing assistance. The valuable suggestions and information furnished by these gentlemen are gratefully acknowledged.

The classifications under which meats are quoted differ slightly in different American cities according to the nature of the supplies received and the peculiarites of the local trade. They are essentially alike, however, at all the great packing centers of this country, and since most American wholesale markets are supplied from these centers, the classification as presented may be regarded as standard.

Market classifications of meat, like those of live stock, are more or less flexible because of the varied and varying conditions which affect the industry. In those branches of the trade in which the current market terms are vague and the classifications loose, the writer has attempted to present the subject as systematically as possible without exaggerating the classification actually in use. It is impracticable to include in this work all the minor and intermediate grades of meat within each class, and only those classes and grades which may be considered standard or representative are described. It is also difficult to describe a grade of meat independently of others within its class. Generally, therefore, each grade should be studied in connection with those above and below it.

Attention is called to the fact that the classifications presented are those of the wholesale meat trade and not of the live stock market, and that they are treated independently of the latter. The weights given refer to dressed carcasses and cuts, and in no case to live animals. Altho in some instances the classes of meat correspond to those of live stock, they are in the main quoted and sold quite separately and differently from the live animals from which they are obtained. It is outside the objects of this work to consider the relation of the animal to its meat products. It is hoped, however, that it will materially assist in placing such investigations on a more exact and uniform basis than would otherwise be possible, and that it will increase the number and significance of future investigations along this line.

The following outlines represent the general classification of beef, veal, mutton, lamb and pork as recognized in wholesale markets.

BEEF

	CLASSES	GRADES
CARCASS BEEF	STEERS	PRIME CHOICE GOOD MEDIUM COMMON
	HEIFERS	PRIME CHOICE GOOD MEDIUM COMMON
	COWS	CHOICE GOOD MEDIUM COMMON CANNERS
	BULLS AND STAGS	CHOICE GOOD MEDIUM COMMON

Miscellaneous

"Native," "Western" and "Texas" Beef
"Yearlings," "Distillers," "Butcher" and "Kosher" Beef
Shipping and Export Beef

BEEF CUTS	LOINS	No. 1,	No. 2,	No. 3,	STRIPPERS
	RIBS	"	"	"	"
	ROUNDS	"	"	"	"
	CHUCKS	"	"	"	"
	PLATES	"	"	"	"
	FLANKS	"	"	"	
	SHANKS	"	"	"	
	SUET				

CURED BEEF PRODUCTS	BARRELED SMOKED CANNED

VEAL

	CLASSES	GRADES
CARCASS VEAL		CHOICE GOOD MEDIUM LIGHT HEAVY

"Native" and "Western" Veal

VEAL CUTS	SADDLES	CHOICE GOOD MEDIUM COMMON
	RACKS	CHOICE GOOD MEDIUM COMMON

MUTTON AND LAMB

	Classes	Grades
CARCASS MUTTON AND LAMB	Wethers	Choice Good Medium Common
	Ewes	Choice Good Medium Common Canners
	Bucks	Good Medium Common
	Yearlings	Choice Good Medium
	Lambs	Choice Good Medium Common Culls
MUTTON CUTS	Saddles Legs Loins	Choice Good Medium Common
	Racks Short Racks Stews	Choice Good Medium Common
	Backs	
LAMB CUTS	Saddles Legs Loins	Choice Good Medium Common
	Racks Short Racks Stews	Choice Good Medium Common
	Backs	

PORK

	CLASSES	GRADES
DRESSED HOGS	SMOOTH HEAVY HOGS	
	BUTCHER HOGS	
	PACKING HOGS	HEAVY MEDIUM LIGHT
	BACON HOGS	CHOICE GOOD COMMON
	SHIPPERS	
	PIGS	
PORK CUTS	HAMS	REGULAR SHORT-CUT SKINNED BONELESS ROLLED REGULAR LONG-CUT STAFFORD MANCHESTER ITALIAN
	SIDES	SHORT RIBS REGULAR JOBBING ROUGH EXTRA SQUARE SHORT CLEARS REGULAR SQUARE EXTRA ENGLISH BACON SIDES WILTSHIRE CUMBERLAND DUBLIN LONG RIB LONG CLEAR YORKSHIRE STAFFORDSHIRE
	BELLIES	DRY-SALT SWEET-PICKLE BREAKFAST-BACON ENGLISH

PORK—Continued

	Classes	Grades
PORK CUTS Continued	Backs	Short Rib Short Clear Short Fat Long Fat
	Loins	Regular Loin Rolls
	Shoulders	Rough Regular Picnic New York Cut Skinned Square New Orleans Cut Boneless Rolled
	Butts and Plates	Boston Style Butts Milwaukee Style Butts Boneless Butts Buffalo StyleButts New York Style Butts Picnic Butts Dry-Salt Butts Square-Cut Butts Regular Plates Clear Plates Back Plates
	Miscellaneous	Mess Pork Belly Pork Back Pork Shoulder Pork Spareribs Trimmings
LARD	Kettle Rendered Leaf	
	Kettle Rendered	
	Neutral	No. 1 No. 2
	Prime Steam	Choice Regular
	Refined	
	Compound	

SUMMARY

The following notes, definitions and illustrations selected from the text of the bulletin will serve to supplement very briefly the foregoing outlines, and are designed to be of interest to those who may not desire the complete bulletin.

BEEF

1. CARCASS BEEF.—This includes both full sides and quarters (Fig. 1.) The classes are *Steers, Heifers, Cows* and *Bulls and Stags*. The classes differ not only in sex but also in the uses to which they are adapted.

The grades within the classes are *prime, choice, good, medium, common and canners*. The grades are based on differences in form, thickness, finish, quality, soundness and weight.

"Native" carcass beef has sufficient finish to indicate grain feeding, is comparatively compact in form, thickly fleshed, mature in proportion to age and consists chiefly of medium to prime steers, heifers and cows of the heavier weights. "Westerns" are relatively "rangy" in form, "grassy" in color and general appearance, coarser in quality and inferior to "natives" in finish, consisting largely of common to good cows and steers. "Texas" beeves are light-weight carcasses inferior to "Westerns" in form, finish and quality, usually bruised and showing considerable age, consisting chiefly of medium, common and canner cows and steers. These terms have much less geographical significance than formerly.

"Yearlings" are carcasses of young steers and heifers of 400 to 700 pounds dressed weight with sufficient quality and finish to be sold at retail on the butcher's block. "Butcher Cattle" are those especially adapted to "butcher shop" trade and consist principally of medium to choice heifers, steers and cows. "Kosher" cattle are beeves that have been slaughtered, inspected, cleansed and labeled in accordance with Jewish rites and include medium to choice steers, cows and heifers. "Distillers" are steers, bulls and stags that have soft, "washy" flesh and "high color" characteristic of cattle fattened on distillery-slops. They are principally of medium and good grades.

"Shipping beef" refers to that sent to eastern cities and consists chiefly of steers, heifers, and cows of medium to prime grades. "Export beef" is made up mainly of medium to choice steers, and includes good and choice heifers, heavy cows, bulls and stags.

2. BEEF CUTS.—The "straight cuts" are *Loins, Ribs, Rounds, Chucks, Plates, Flanks* and *Shanks*. (Fig. 1.)

The grades of beef cuts are *No. 1, No. 2, No. 3* and *Strippers*. The grade of a cut depends upon its thickness, covering, quality, and weight.

CARCASS WEIGHT

	Plates	Flanks	Shanks	Suet
21–27	12–16	2–5	3–7	2–7
26	13	4	4	4

Various other wholesale cuts are made from the "straight" cuts, and in general are graded in a similar manner. (Fig. 1.)

3. CURED BEEF PRODUCTS.—These are (1) Barreled, (2) Smoked and (3) Canned Beef.

Barreled beef is packed in brine. The standard grades are *Extra India Mess, Extra Plate, Regular Plate, Packet, Common Plate, Rolled Boneless, Prime Mess, Extra Mess, Rump Butt* and *Mess Chuck Beef, Beef Hams* and *Scotch Buttocks.*

Smoked Beef is cured in sweet pickle, dried and smoked. It consists of *Dried Beef Hams, Dried Beef Clods* and *Smoked Brisket Beef.*

Canned Beef is sealed in tins or glass jars, usually after partial curing and cooking. It consists principally of *Chipped Beef, Beef Loaf, Corned Beef* and *Roast Beef.*

VEAL

1. CARCASS VEAL.—This consists of whole carcasses, which are usually sold with the skin on.

The grades are *choice, good, medium, light* and *heavy*. The grade of a carcass is determined by its form, quality, finish and weight.

"Native" calves have white, fine-grained flesh and long, soft hair. "Westerns" have comparatively coarse, dark-colored flesh, "rangy" form and short, straight hair.

2. VEAL CUTS.—The regular cuts are *Saddles* and *Racks.* Each is about one-half, by weight, of the skinned carcass. (Fig. 2.) They are graded as *choice, good, medium* and *common,* according to the same factors as carcass veal.

Subdivisions of the regular cuts are made in some markets, and similarly graded. (Fig. 2.) Veal legs and stews each contain about one-third the carcass weight; ribs and loins about one-sixth each.

MUTTON AND LAMB

1. CARCASS MUTTON AND LAMB.—The classes are *Wethers, Ewes, Bucks, Yearlings* and *Lambs.* The classification is based on differences in sex and degree of maturity.

The grades within the classes are *choice, good, medium, common* and *culls.* The grade of a carcass is determined by its form, quality, covering and weight.

The shipping trade goes principally to cities in the eastern seaboard states and consists largely of medium to choice lambs.

2. MUTTON AND LAMB CUTS.—*Saddles and Racks* are the cuts most commonly made; but *Legs, Loins, Short Racks, Stews* and *Backs* are also quite extensively sold. (Fig. 3.) These cuts are graded as *choice, good, medium* and *common* according to their shape, quality, covering and weight. In relative weights, the various cuts are similar to the corresponding cuts of veal.

PORK

1. DRESSED HOGS.—The classes are *Smooth Heavy, Butcher, Packing,* and *Bacon Hogs, Shippers,* and *Pigs.* The classification is based on the uses to which the hogs are adapted.

Distinct grades are recognized only in the *Packing* and *Bacon* classes, the former being based on weight and the latter chiefly on quality and finish.

2. PORK CUTS.—The classes are *Hams, Sides, Bellies, Backs, Loins, Shoulders, Butts and Plates,* and *Miscellaneous,* these being determined by the parts of the carcass from which they are made. (Fig. 4.)

The grades and methods of grading vary widely in the different classes of cuts, and involve not only their quality, shape, finish and weight, but also the styles of cutting and methods of packing used.

Pork cuts are quoted as fresh pork, dry-salt and bacon meats, barreled or plain-pickled pork, sweet-pickled meats, smoked meats, "English" meats and boiled meats, respectively.

3. LARD.—The grades are *Kettle-Rendered Leaf, Kettle-Rendered, Neutral, Prime Steam, Refined* and *Compound Lard.* The grading is based on the kinds of fats included, method of rendering, color, flavor and grain.

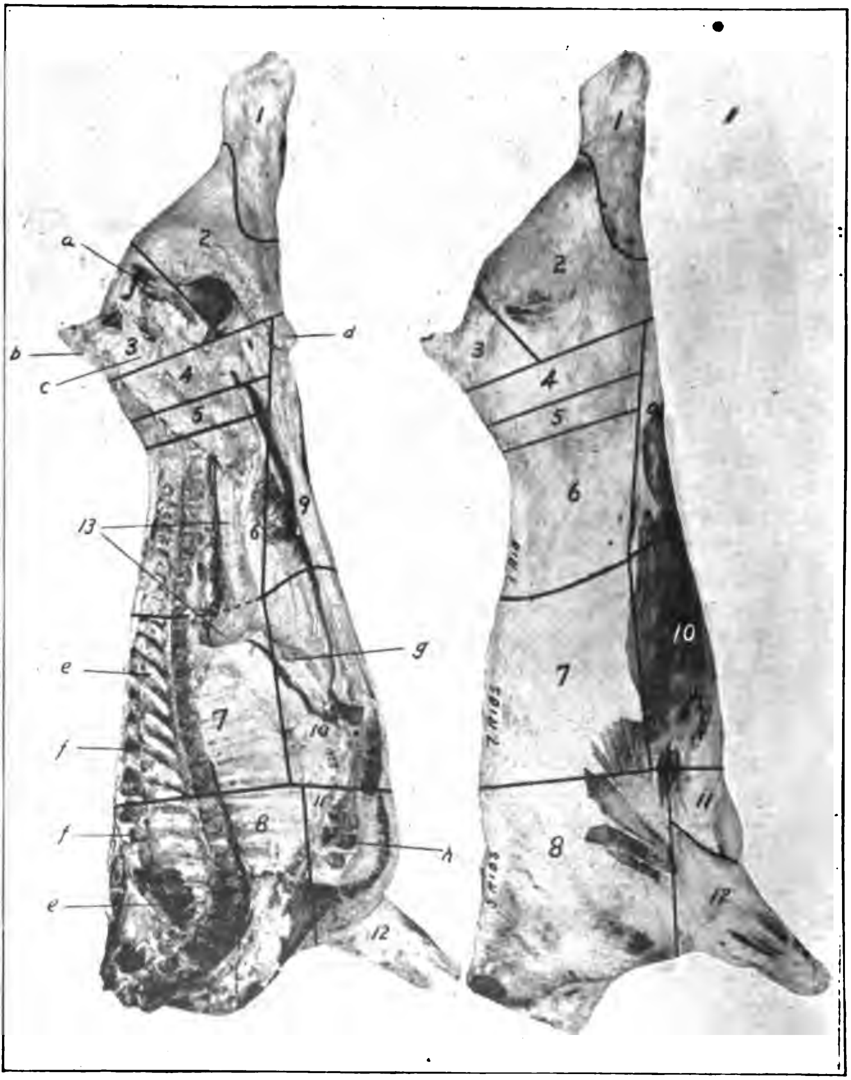

FIG. 1. BEEF CUTS.

1, 2, 3.	**Round**	1.	**Hind shank**	1, 2, 3, 4,		**a. Aitch-bone**
4, 5, 6.	**Loin**	2.	**Round, R. & S. off**	5, 6, 9.	**Hind quarter**	**b. Rump-bone**
7.	**Rib**	3.	**Rump**	7, 8, 10,		**c. Crotch**
8.	**Chuck**	4, 5.	**Loin end**	11, 12.	**Fore quarter**	**d. Cod**
9.	**Flank**	6.	**Pinbone loin**	7, 8.	**Back**	**e. Chine-bones**
10, 11.	**Plate**	5, 6.	**Flatbone loin**	7, 10.	**Piece**	**f. "Buttons"**
12.	**Shank**	10.	**Navel**	8, 11, 12.	**Kosher chuck**	**g. Skirt**
13.	**Suet**	11.	**Brisket**	8, 10, 11, 12.	**Triangle**	**h. Breast-bone**

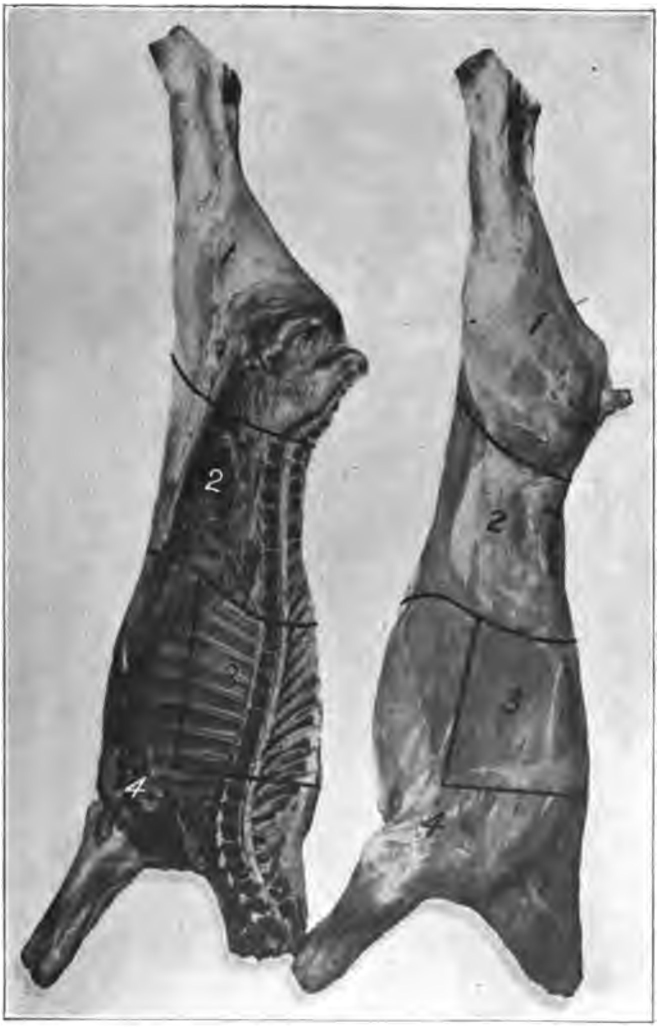

FIG. 2. VEAL CUTS.

1, 2. Saddle (or 2 hind quarters).	1. Leg 2. Loin
3, 4. Rack (or 2 fore quarters).	3. Ribs 4. Stew

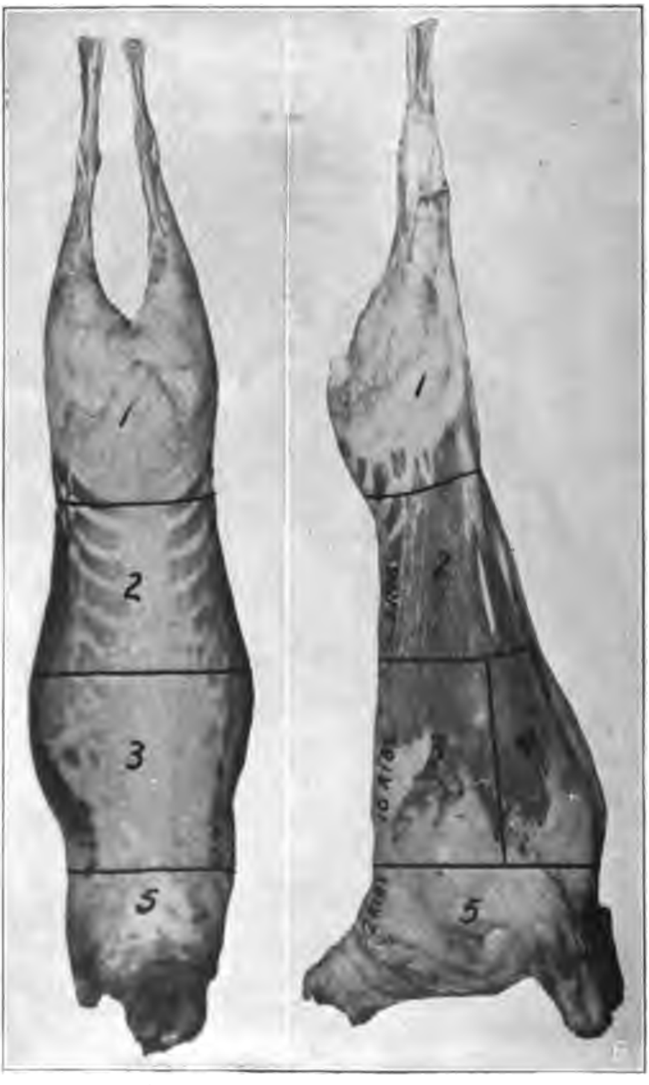

FIG. 3. MUTTON AND LAMB CUTS.

1, 2.	**Saddle**	**1.**	**Leg**	**4.**	**Breast**
3, 4, 5.	**Rack**	**2.**	**Loin**	**5.**	**Chuck**
1, 2, 3.	**Long saddle**	**3.**	**Short rack**	**4, 5.**	**Stew**
2, 3, 4, 5.	**Body**	**2, 3.**	**Back**		

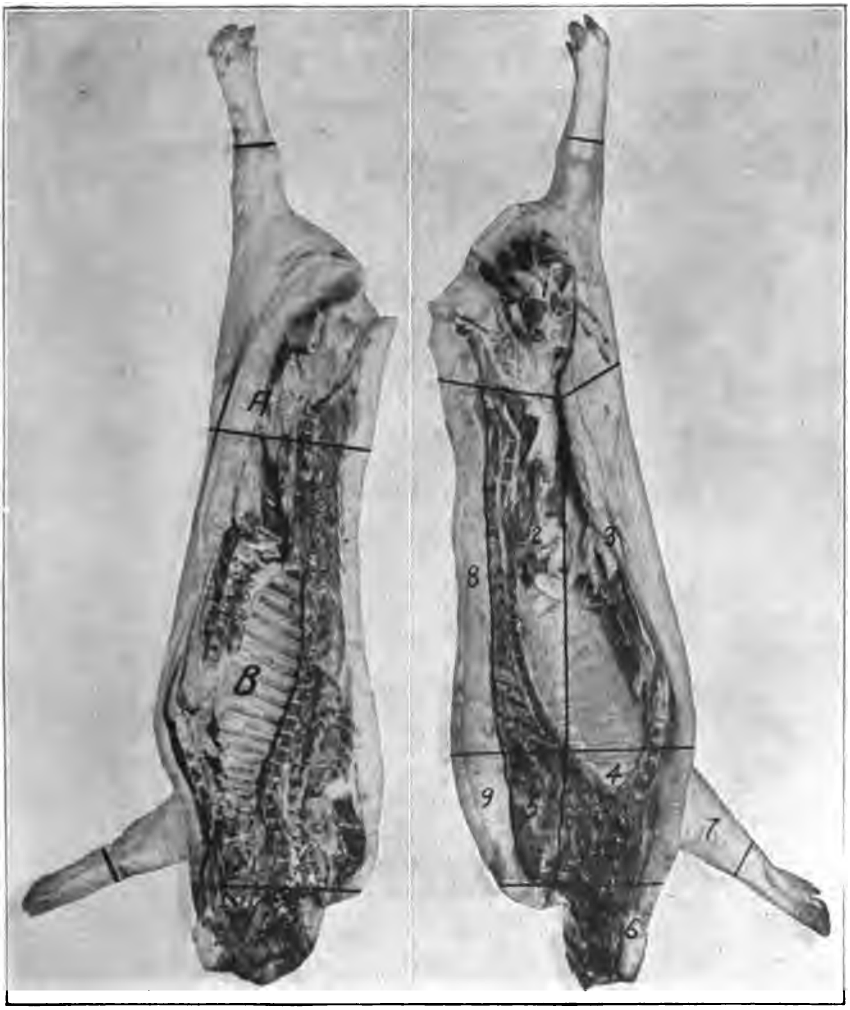

FIG. 4. PORK CUTS.

ENGLISH CUTS

A. Long-cut ham
B. Long side or middle

DOMESTIC CUTS

1.	Short-cut ham	6.	Jowl	2, 3, 8.	Side
2.	Loin	7.	Hock	4, 7.	Picnic shoulder
3.	Belly	8.	Fat back	5, 9.	Shoulder butt
4.	Picnic butt	9.	Clear plate	8, 9.	Long fat back
5.	Boston butt	2, 8.	Back	4, 5, 7, 9.	Rough shoulder

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UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 148

ON THE MEASUREMENT OF CORRELATION WITH SPECIAL REFERENCE TO SOME CHARACTERS OF INDIAN CORN

By HENRY L. RIETZ AND LOUIE H. SMITH

URBANA, ILLINOIS, NOVEMBER, 1910

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CONTENTS OF BULLETIN NO. 148

PAGE

Introduction .... [illegible]91
The Correlation Table 292
Nature of the correlation coefficient r.................... 294
Details of the computation of the correlation coefficient 296
Modification of the method of computing r.................... 301
Probable error 301
Use of the correlation coefficient 301
The regression coefficient 302
Use of the regression coefficient 302
Determination of the correlation coefficients for certain physical characters in corn 303
Source of material 304
Discussion of results 306
  Two year rotation corn 306
  Illinois corn 307
Appendix on the Mathematical Theory of Correlation.................... 309
  Mathematical definition of correlation 309
  Standard deviation of arrays 311
  Correlation surfaces .... 31[illegible]
  Derivation of the shorter formula for numerical calculation of r...... 3[illegible]

ON THE MEASUREMENT OF CORRELATION WITH SPECIAL REFERENCE TO SOME CHARACTERS OF INDIAN CORN

By HENRY L. RIETZ, Statistician, and LOUIE H. SMITH, Assistant Chief, Plant Breeding

INTRODUCTION

In Bulletin 119 of this station, there are presented methods of dealing with problems involving variability of a single character and these methods are there applied to the study of type and variability of some characters in corn.

But the breeder deals with many characters in the same organism, each with its own variability. After treating separate characters, what he needs next to know is whether, and to what extent, any bond may exist between characters by virtue of which, if one character varies, other characters of the same organism tend also to move in the same or in opposite directions.

If such a bond exists the characters are said to be correlated (co-related), and it is the purpose of this bulletin to describe methods by which such a correlation may be detected if present and the strength of its bond be measured.

A second purpose of the bulletin is to present data concerning certain definite correlations for corn bred at the Illinois Station.

The great value to the breeder of definite knowledge of correlations within a species is that it gives reliable information, enabling him to predict from the presence of certain characters the most probable values of associated characters.

More technically speaking, when we are dealing with two systems of variable characters in correspondence, we are, in general, much concerned about whether fluctuations of variates in one system are in sympathy with fluctuations of corresponding variates in the other, and with establishing causal relations between the two series of phenomena. For example, in breeding corn for commercial purposes, we are much interested in knowing what characters of the seed ears should be modified or selected to increase the yield; and, if we should select directly one character, it is important to know to what extent other characters are being selected indirectly, because of the tendency of the two to fluctuate in the same or in opposite directions.

These examples illustrate the following technical definition of *correlation; Two characters*—say length and circumference of ears of corn—*are said to be correlated when with any selected values* (x) *of the one character, we find that values of the other character, a given amount above and below the mean of that character, are not equally likely to be associated.*

As the first and simplest method, it may possibly occur that correlation is so pronounced that it may be necessary merely to look at two sets of figures to note that corresponding values have a tendency to change simultaneously in the same or in opposite directions. The existence of such decided correlation may be known by inspection.

As a second, and somewhat more effective method, one may plot curves for each of two systems of variates, and if correlation is very pronounced, it may sometimes be discovered by noting whether the curves have a tendency to rise and fall together, or if, when one rises, the other falls.

Not only do these methods prove inadequate to detect correlation unless it is exceedingly pronounced, but they lack precision in that they do not give a measure of correlation. It is not enough to know whether correlation exists, its quantitative measure is usually a matter of importance.

Our power to measure the correlations among associated phenomena has been enormously increased during the past two decades by methods introduced by Galton and developed by Pearson and those associated with him. An application of these methods has not until very recently been made to problems in agriculture.*

It is the purpose of this Bulletin to present in a form useful to agricultural students the methods of correlation measurement without presuming more mathematics than is absolutely necessary, and to give the results of our investigations into the correlation of certain characters in corn bred at the Illinois Station.

1. The Correlation Table.—The first step in the process of measuring correlation is to construct a double entry table (Fig. 1) —called a "correlation table"—out of the measurements of the characters in a large number of individuals. One mark at the intersection of the proper column and row in the table records a pair of corresponding variates with reference to two characters.

Put in tabular form as it appears in the actual work, we have the following (Fig. 1) for the correlation table between the num-

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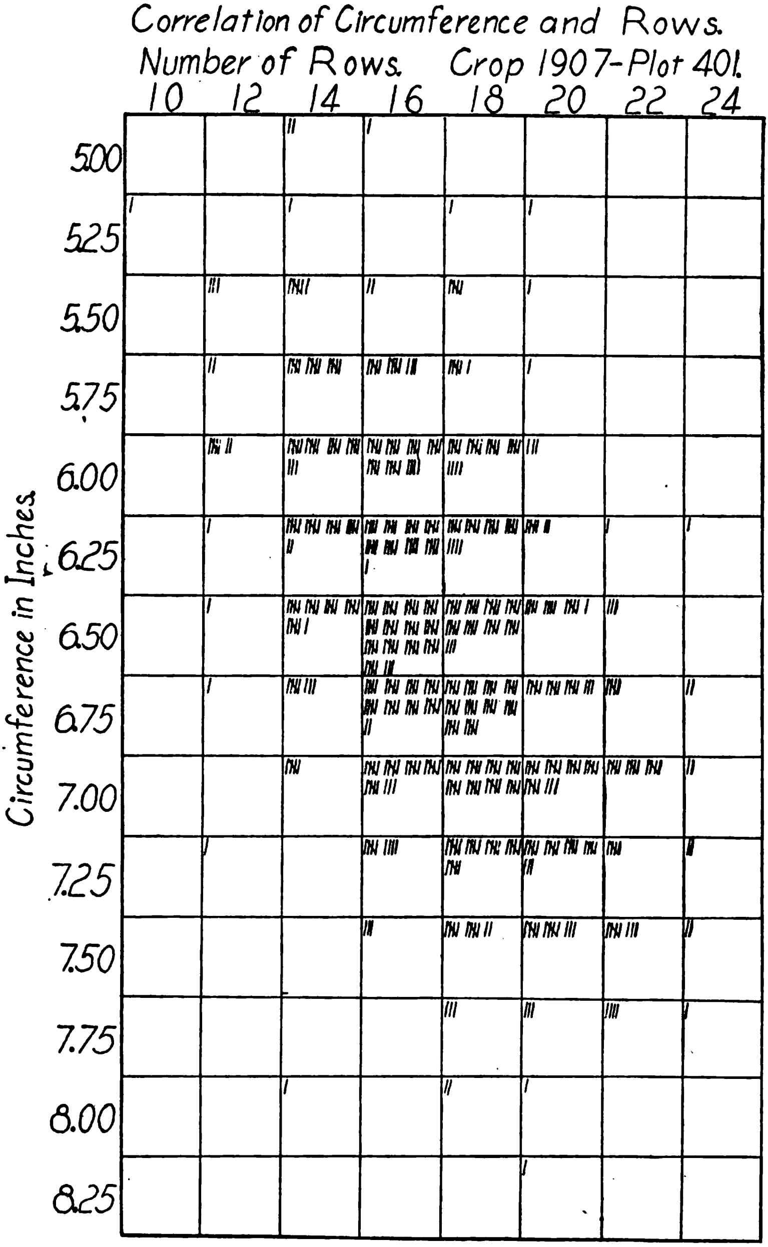
*Davenport, *Principles of Breeding*, pp. 452-472, 703-711.
Pearl and Surface, *Bulletin 166, Maine Agr. Exp. Sta.*
Clark, *Bulletin 279, Cornell University Agr. Exp. Sta.*



Correlation of Circumference and Rows.

Number of Rows. Crop 1907-Plot 401.

Circumference in Inches	10	12	14	16	18	20	22	24
5.00			||	|				
5.25	|		|		|	|		
5.50		|||	𝍸 |	||	𝍸	|		
5.75		||	𝍸 𝍸 𝍸	𝍸 𝍸 ||	𝍸 |	|		
6.00		𝍸 ||	𝍸 𝍸 𝍸 𝍸 |||	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	𝍸 𝍸 𝍸 𝍸 ||||	|||		
6.25		|	𝍸 𝍸 𝍸 𝍸 ||	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 |	𝍸 𝍸 𝍸 𝍸 ||||	𝍸 ||	|	|
6.50		|	𝍸 𝍸 𝍸 𝍸 𝍸 |	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 ||	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 |||	𝍸 𝍸 𝍸 |	|||	
6.75		|	𝍸 |||	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 ||	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	𝍸 𝍸 𝍸 |||	𝍸	||
7.00			𝍸	𝍸 𝍸 𝍸 𝍸 𝍸 |||	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	𝍸 𝍸 𝍸 𝍸 𝍸 |||	𝍸 𝍸 𝍸	||
7.25		|		𝍸 ||||	𝍸 𝍸 𝍸 𝍸 𝍸	𝍸 𝍸 𝍸 𝍸 ||	𝍸	||
7.50				|||	𝍸 𝍸 ||	𝍸 𝍸 |||	𝍸 |||	||
7.75					|||	|||	||||	|
8.00			|		||	|		
8.25						|		

FIG. 1.

ber of rows of kernels on ears and the circumference of the ears for a certain plat of corn (Plot 401) grown in 1907 at the Illinois Experiment Station.

It will be observed that this table consists of a double system of arrays each of which is a frequency distribution as explained in Bul. 119, and has its own mean and standard deviation as has any other frequency distribution.

To show, in a concrete way, how such a table is made, suppose an ear of corn has 18 rows of kernels and a circumference between 6.375 and 6.625 in., a mark is made in the rectangle at the intersection of the column headed 18 and the row of the table marked 6.50. A second table (Fig. 2) exhibits the result of counting the marks in each of the rectangles of Fig. 1.

Any number in this table, say 43, in the column headed 18 and the row marked 6.50, indicates that 43 ears of the total of 769 ears had 18 rows of kernels and a circumference of class mark 6.50.

By adding the numbers in horizontal arrays, we obtain the frequency distribution of the population with respect to circumference of ears, and by adding the numbers in columns, we obtain the frequency distribution of the population with respect to rows of kernels on ears (See Fig. 3).

The mere superficial inspection of a correlation table may suggest that a certain amount of correlation exists. For example, ears of corn of circumference 7.50 inches, from this population, are much more likely to have 20 rows of kernels than are ears of circumference 6 inches. It is pretty clear that there is a tendency, in general, for the marks in the table of Fig. 1 to arrange themselves in a region along the diagonal from the upper left hand corner to the lower right hand corner of the table. This signifies that a positive correlation exists; that is, in general, for this population, ears that have a large number of rows of kernels are more likely to be large in circumference than are ears with a smaller number of rows of kernels. But it is not our purpose merely to detect the existence of correlation. What we seek is a statistical *coefficient* that will serve to measure correlation, and that will enable us to predict with as high a degree of probability as possible, from an assigned character, the value of the associated character in the related system of variates. The coefficient of correlation, denoted by r in this paper, is useful for this purpose.

2. Nature of the coefficient r.—A discussion of the mathematical theory of correlation will be given in the Appendix to this Bulletin, but the general character and common sense significance of r may well be stated here. The value of the coefficient is within the limits —1 and +1. If r=1, there is said to be perfect positive

Correlation of Circumference and Rows.
Number of Rows. Crop 1907—Plot 401.

Circumference in Inches.	10	12	14	16	18	20	22	24
5.00			2	1				
5.25	1		1		1	1		
5.50		3	6	2	5	1		
5.75		2	15	13	6	1		
6.00		7	23	34	24	3		
6.25		1	22	41	24	7	1	1
6.50		1	26	68	43	16	3	
6.75		1	8	42	50	18	5	2
7.00			5	28	40	28	15	2
7.25		1		9	25	23	5	2
7.50				3	12	13	8	2
7.75					3	3	4	1
8.00			1		2	1		
8.25						1		

FIG. 2.

correlation; that is, for any assigned value of the character in one system, the value for each corresponding individual of the related system is known, and the ratio of the deviations of any two variates of a pair from their mean values is a constant for all pairs. In other words, perfect correlation ($r=1$) indicates complete causation in the sense that the two characters go together perfectly. If $r=-1$, there is said to be perfect negative correlation. In this case, the ratio of the deviations from mean values are *negative* and constant for all pairs. If no correlation exists, the two characters appear indifferent to each other, and this fact is expressed by $r=0$. In a general way, we may say that the correlation should be judged, in any application, by the value that r takes between -1 and $+1$. For our applications to characters in corn, there is usually a positive correlation, and the amount of correlation is measured by the value of r between 0 and 1.

The correlation coefficient may be defined as the mean product of deviations of corresponding variates from their mean values in units of the standard deviations.

The meaning of the standard deviation of a frequency distribution is shown in Bulletin 119 of this Station. If a variate is below the mean, its deviation is negative; while if it is above the mean, it is positive. Hence, if each individual of a pair of variates is above the mean of the system to which it belongs, or if each of the pair is below, the pair tends to contribute to positive correlation. On the other hand, if one variate of a pair is below the mean of its system and the other above, the product is negative, and such a pair tends to contribute to negative correlation. While it appears from this that the coefficient of correlation, as defined above, has a common sense justification, we shall require the mathematical methods of the Appendix to see more fully how this coefficient with the standard deviations of the two systems of variates are descriptive of the correlated population exhibited on a correlation table such as is shown in Fig. 1.

3. **Details of the computation of r.**—In algebraic form

$$r = \frac{\sum xy}{n\sigma_x \sigma_y} \quad \text{- - - -} \ (1)$$

where $\sum xy$ means the sum of the products of the deviations of corresponding variates from their mean values; and σ_x, σ_y are standard deviations, while n is the number of pairs of variates.

As we shall use the correlation table of Fig. 2 to illustrate a systematic arrangement of the work in the computation of r, the formula (1) may appear more significant in the application by writing it in the form

$$r = \frac{\sum D_C D_R}{n\sigma_C \sigma_R} \quad - - - - (2)$$

where the subscripts c and R refer to circumference and rows of kernels respectively, while the D's represent deviations of characters indicated by subscripts. That is to say, D_c is the deviation of the circumference of an ear from the mean circumference, and D_R the deviation of the number of rows of kernels from the mean of the number of rows of kernels.

There is derived in the Appendix, pp. 313-314, a formula which gives the same numerical value as

$$\frac{\sum xy}{n\sigma_x \sigma_y} \quad \text{or} \quad \frac{\sum D_C D_R}{n\sigma_C \sigma_R},$$

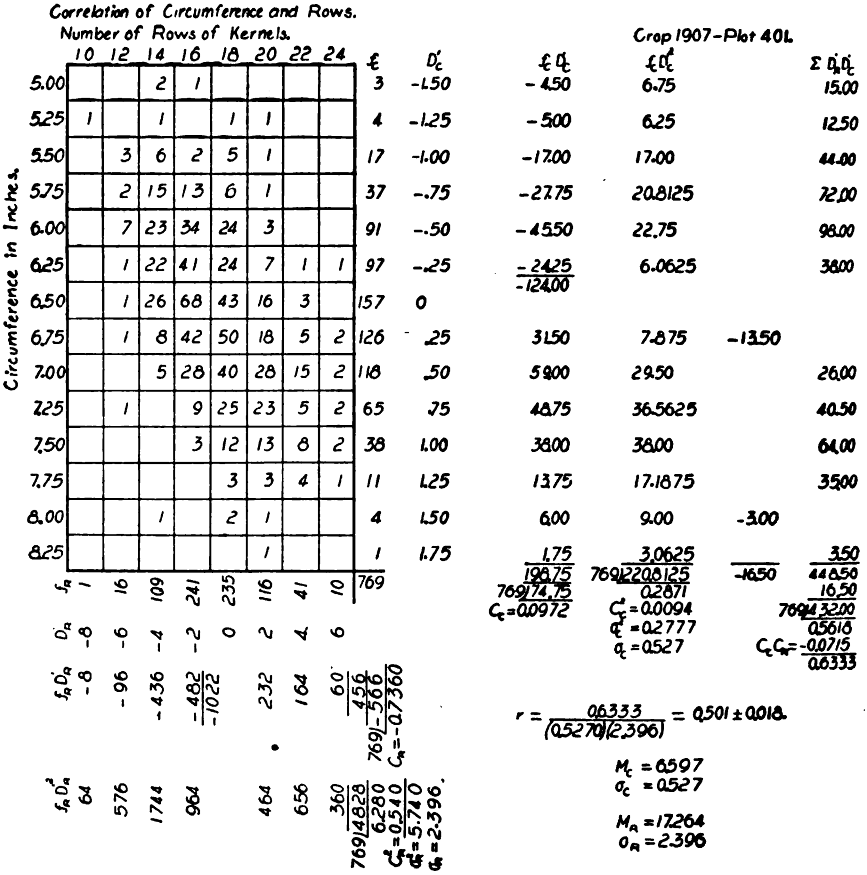
and, while its algebraic expression is a little more complicated, it is much better adapted to numerical computation than the above formula, as it avoids the use of decimals until almost the end of the work. In this respect, it is analogous to the shorter method presented in Bulletin 119 for finding the mean and the standard deviation. If applied to the case of the number of rows of kernels and circumference of ears of corn, the formula is

$$r = \frac{1}{\sigma_C \sigma_R}\left(\frac{\sum D_R' D_C'}{n} - c_R c_C\right) \quad - - - - (3)$$

where D_R', D_c' are deviations from our guesses at the means instead of deviations from the means themselves; and C_R, C_c are the corrections applied to the guesses at the mean number of rows of kernels and circumference respectively in finding the means and standard deviations.

In the actual work of calculating r from formula (3), it is highly important to have a systematic form in which to arrange the work, in order to avoid confusion in the somewhat complicated details. It seems desirable, for this reason, to describe the arrangement of the actual work as shown in Fig. 3.

Having given the correlation table, we first add the numbers in the arrays with respect to both characters; that is, add numbers in rows and columns of the table. This gives two frequency distributions—the one with respect to circumference exhibited in the vertical column headed f_c, and the other with respect to rows of kernels shown in the horizontal column of figures marked f_R. For each of these frequency distributions, the *means and standard deviations* are calculated by the shorter method explained and applied in Bulletin 119.



Correlation of Circumference and Rows.

Crop 1907—Plot 40L

Circumference in Inches. \ Number of Rows of Kernels.	10	12	14	16	18	20	22	24	f_c	D'_c	$f_cD'_c$	$f_cD'^2_c$		$\Sigma D'_R D'_c$
5.00			2	1					3	-1.50	-4.50	6.75		15.00
5.25	1		1		1	1			4	-1.25	-5.00	6.25		12.50
5.50		3	6	2	5	1			17	-1.00	-17.00	17.00		44.00
5.75		2	15	13	6	1			37	-.75	-27.75	20.8125		72.00
6.00		7	23	34	24	3			91	-.50	-45.50	22.75		98.00
6.25		1	22	41	24	7	1	1	97	-.25	-24.25 -124.00	6.0625		38.00
6.50		1	26	68	43	16	3		157	0				
6.75		1	8	42	50	18	5	2	126	.25	31.50	7.875	-13.50	
7.00			5	28	40	28	15	2	118	.50	59.00	29.50		26.00
7.25		1		9	25	23	5	2	65	.75	48.75	36.5625		40.50
7.50				3	12	13	8	2	38	1.00	38.00	38.00		64.00
7.75					3	3	4	1	11	1.25	13.75	17.1875		35.00
8.00			1		2	1			4	1.50	6.00	9.00	-3.00	
8.25						1			1	1.75	1.75	3.0625		3.50
f_R	1	16	109	241	235	116	41	10	769		198.75	769)220.8125	-16.50	448.50
D'_R	-8	-6	-4	-2	0	2	4	6			769)74.75	0.2871		16.50
$f_RD'_R$	-8	-96	-436	-482 -1022		232	164	60 456			C_c=0.0972	C_c^2=0.0094		769)432.00
$f_RD'^2_R$	64	576	1744	964		464	656	360				σ_c^2=0.2777		0.5618
												σ_c=0.527		C_cC_R=-0.0715 0.6333

769)-566
C_R=-0.7360

769)4828
6.280
C_R^2=0.540
σ_R^2=5.740
σ_R=2.396.

$$r=\frac{0.6333}{(0.5270)(2.396)}=0.501\pm0.018.$$

M_c = 6.597
σ_c = 0.527

M_R = 17.264
σ_R = 2.396

FIG. 3.

The results are

$$M_c = 6.597,$$
$$\sigma_c = 0.527,$$
$$M_R = 17.264,$$
$$\sigma_R = 2.396,$$

where M_c, M_R represent mean circumference and mean number of rows of kernels respectively, while σ_c, σ_R are corresponding standard deviations.

The columns of figures marked f_c, D_c', f_cD_c', $f_cD_c'^2$, f_R, D_R', f_RD_R', $f_RD_R'^2$ are all self explanatory to one familiar with the meaning of algebraic symbols, and who knows how to find the mean and standard deviation.

There remains the column of figures headed $\sum D'_R\ D_c'$, which we shall endeavor to explain in detail, as this is the only part of the computation that is actually new to one who knows how to calculate the variability of a population. In finding the means, we get the deviations of class marks from our guesses at mean circumference and mean number of rows of kernels on ears of corn. These deviations are marked D_c', D_R'. For example, in row 1, we find 3 ears of circumference 5 inches. These three ears deviate —1.50 from our guesses at the mean circumference.

We next form the product of each number of the correlation table and of the two corresponding deviations. For example, where the column is headed 16 and the row is labelled 6.00 inches intersect, occurs the number 34. These 34 ears have deviations from our guesses of —0.50 and —2 as is indicated by the symbols D_c' and $D\ '$. Hence, for this number 34, we form the product $34(-0.50)(-2)=+34$. Without regard to labor, we should find such a product for each compartment of the correlation table. The sum of these products, with due regard to signs, is the $\sum D_R'D_c'$ of formula (3). The systematic way to carry out this work is to record the results of this operation for each horizontal array in line with the array under the heading $\sum D_R'D_c'$, and then to add the results for separate arrays to obtain 432.00 which is symbolically ndicated by $\sum D_R'D_c'$.

To illustrate the method of calculation, let us take the array of circumference 6.00 inches as an example. We have, for this array,

$$\left.\begin{array}{r} -6\times7\\ -4\times23\\ -2\times34\\ 0\times24\\ 2\times3 \end{array}\right\}\times(-0.50)$$

This gives 98.00,

For the array of mark 6.75

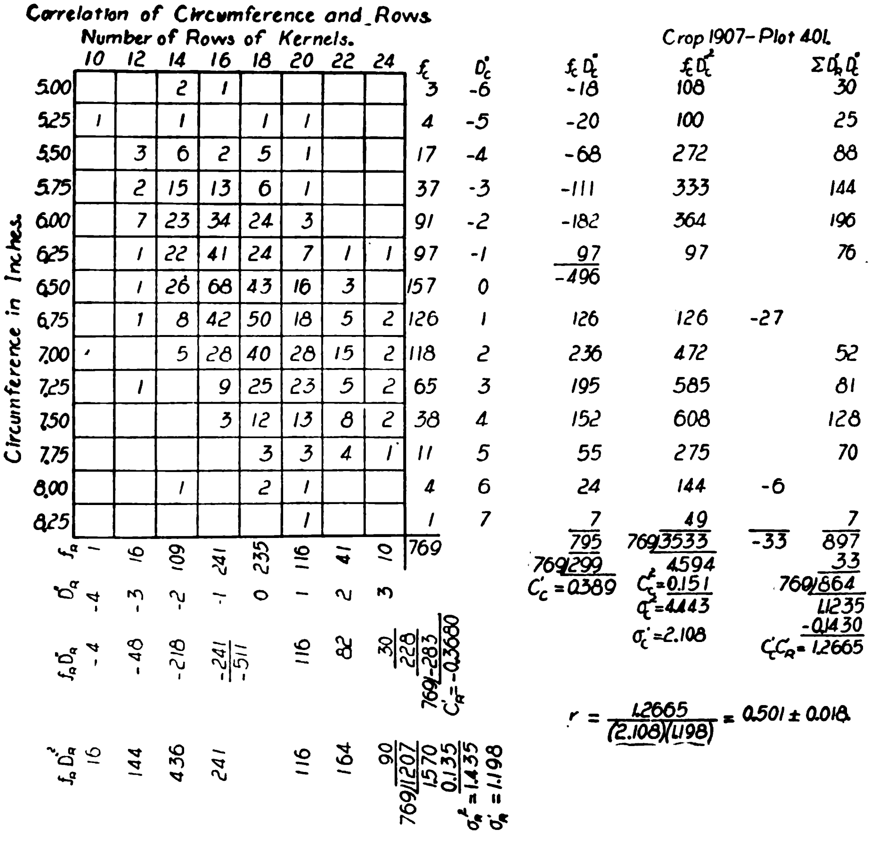
$$\left.\begin{array}{r} -6\times1\\ -4\times8\\ -2\times42\\ 0\times50\\ 2\times18\\ 4\times5\\ 6\times2 \end{array}\right\}\times(0.25)$$

This gives —13.50.

Treat all arrays in this manner, and divide the sum of the products thus obtained (that is, 432.00) by the number of variates 769. This gives $\frac{\sum D_c' D_R'}{n}$ of formula (6) and equals 0.5618.

Next, we subtract from this the product of our two corrections in finding means. That is, $C_R C_c = -0.0715$.
To subtract this negative number, we must add 0.0715. This gives 0.6333 for the numerical value of $\frac{\sum D_c' D_R'}{n} - C_c C_R$.

$$r = \frac{1}{\sigma_R \sigma_c}\left(\frac{\sum D_c' D_R'}{n} - C_c C_R\right) = 0.501.$$



Correlation of Circumference and Rows

Crop 1907 – Plot 401.

Circumference in Inches	Number of Rows of Kernels. 10	12	14	16	18	20	22	24	f_c	D_c'	$f_c D_c'$	$f_c D_c'^2$		$\Sigma D_R' D_c'$
5.00			2	1					3	-6	-18	108		30
5.25	1		1		1	1			4	-5	-20	100		25
5.50		3	6	2	5	1			17	-4	-68	272		88
5.75		2	15	13	6	1			37	-3	-111	333		144
6.00		7	23	34	24	3			91	-2	-182	364		196
6.25		1	22	41	24	7	1	1	97	-1	97 -496	97		76
6.50		1	26	68	43	16	3		157	0				
6.75		1	8	42	50	18	5	2	126	1	126	126	-27	
7.00			5	28	40	28	15	2	118	2	236	472		52
7.25		1		9	25	23	5	2	65	3	195	585		81
7.50				3	12	13	8	2	38	4	152	608		128
7.75					3	3	4	1	11	5	55	275		70
8.00			1		2	1			4	6	24	144	-6	
8.25						1			1	7	7	49		7
											795 769)299 $C_c' = 0.389$	769)3533 4.594 $C_c'^2 = 0.151$ $\sigma_c^2 = 4.443$ $\sigma_c' = 2.108$	-33	897 33 769)864 1.1235 -0.1430 $C_c C_R = 1.2665$
f_R	1	16	109	241	235	116	41	10	769					
D_R'	-4	-3	-2	-1	0	1	2	3						
$f_R D_R'$	-4	-48	-218	-241 -511		116	82	30 228 769)-283 $C_R' = -0.3680$						
$f_R D_R'^2$	16	144	436	241		116	164	90 769)1207 1.570 0.135 $\sigma_R^2 = 1.435$ $\sigma_R' = 1.198$						

$$r = \frac{1.2665}{(2.108)(1.198)} = 0.501 \pm 0.018$$

Fig. 4

4. **Modification of the method of computing r (Fig. 4).**—The computation of r may, in general, be further simplified by taking the difference between two successive class marks as the unit of measurement. That is, the units of grouping are the units throughout. Then, as shown in Fig. 4, the deviations from the guesses are consecutive integers. This method gives precisely the same value for the correlation coefficient as that explained under Fig. 3. But the standard deviations and the corrections to guesses at the means are expressed in terms of differences between consecutive classes as units. When thus expressed, we note on Fig. 4, that

$$\sigma_c' = 2.108,$$
$$\sigma_R' = 1.198.$$

Where σ_c' is the standard deviation in circumference (expressed in units equal to the difference between classes) and σ_R' is the standard deviation in rows of kernels (similarly expressed). To express σ_c' in inches, we must multiply by 0.25. This gives $\sigma_c = 0.527$ as before.

Similarly, to make σ_R' consistent with σ_R of figure 3, we must multiply by 2. This gives

$$\sigma_R = 2.396.$$

5. **Probable error.**—It still remains to find the probable error in our computed value. The general meaning of the probable error, and its use in indicating the degree of confidence to be placed in a result obtained from a random sample of a population has been given in Bulletin 119. It seems sufficient here to give merely the formula for the probable error in the coefficient of correlation r. This formula is

$$E_r = \pm \frac{0.6745\,(1 - r^2)}{\sqrt{n}}$$

Applied to our example, $E_r = \dfrac{0.6745\,[1 - (0.501)^2]}{\sqrt{769}}$

$$= 0.018$$

Hence, we write

$$r = 0.501 \pm 0.018$$

as the measure of the correlation in question.

6. **Use of the correlation coefficient.**—The general use of such a precise measure of correlation as is given by r, has perhaps been sufficiently discussed in the introduction. However, it seems well to emphasize here that in the selection of one character, we, in general, indirectly select correlated characters, and change their means and standard deviations accordingly. Again, if in

the selection of what the breeder conceives to be the most desirable type for parents, he artificially increases or decreases correlations between characters, this process will, in general, change the correlation between these characters in parents and in offspring. For example, it appears that the correlation between length of ears and circumference for different types of corn which we have examined varies between the limits 0.128 and 0.623. Now, we have examined cases in connection with this work where 48 parents are selected so as to exhibit a negative correlation of —0.21 between length and circumference. If we use the offspring of such a set of 48 ears and ask to what extent length and circumference are inherited, or if we ask to what extent these characters in the parent are correlated with the yield, it is pretty clear that we have much complicated our problem by the selection and imposition of the correlation —0.21. Hence, it is highly desirable to know what correlations actually exist among different characters, before we should expect to obtain in even an approximately precise way the correlation between parent and offspring (inheritance) or the correlation between characters in the parent and yield.

7. The regression coefficient.—From the correlation coefficient and the standard deviations of each of the two characters, it is easy to obtain what is known as the *regression* coefficient. For example, to obtain the regression coefficient of circumference relative to the number of rows of kernels, multiply the coefficient of correlation by the standard deviation in circumference and divide the product by the standard deviation in the number of rows of kernels. This gives, for the particular example above,

$$r\frac{\sigma_C}{\sigma_R} = 0.110.$$

Similarly, the regression of the number of rows of kernels relative to the circumference of ears is

$$r\frac{\sigma_R}{\sigma_C} = 1.200.$$

8. Use of the regression coefficient.—In many systems of correlated variates, the regression is of a kind described in the appendix as *linear regression.* In such cases, the regression coefficient gives us a useful method of predicting, from a given value of one character, the most probable value of the corresponding correlated character. That is to say, from the selected value of one character, we calculate the mean value of the corresponding array.

For the particular case in hand, suppose we select ears with twenty rows of kernels, such ears deviate 2.736 above the mean number of kernels on ears, the regression coefficient (0.110) of circumference on number of rows of kernels indicates that we should expect the mean circumference of ears of 20 rows of kernels to be (0.110) (2.736)=0.301 inches above the mean circumference for the entire population. That is, ears with 20 rows should have a mean circumference

$$6.597+0.301=6.898.$$

By actual computation, the mean of the array of class mark 20 rows is 6.927±0.121, so that the regression coefficient gives the mean of the array to within deviations due to random sampling.

To be more general, if we select an ear of any deviation x in the number of rows of kernels from the mean, we should expect the deviations in circumference of corresponding ears to center about 0.110x.

Similarly, if we select an ear of any deviation y in circumference from the mean circumference, we should expect the deviation in number of rows of kernels to center about

$$1.20\ y.$$

In beginning the discussion of the use of the regression coefficient, we limited our remarks to linear regression. This means that if the correlation table is constructed to scale, and the mean values of arrays be plotted, these mean values will lie along a straight line to within deviations to be attributed to random sampling. Fortunately, this condition is, in general, well satisfied in our applications.

It is important in every case to examine the correlation table to ascertain whether the means of systems of parallel arrays lie reasonably near a straight line.

9. Determination of the correlation coefficients for certain physical characters in corn.—Corn grown on experimental plots of the Illinois Station in 1907, 1908, 1909, furnishes the material for the present study of the correlation between physical characters in corn, and for the problem of quantitative laws of inheritance of these characters. It should be understood that the problem of inheritance is a problem of the correlations between ancestry and offspring. The characters with which we propose to deal here are: length, weight, circumference of ears, and the number of rows of kernels on ears.

While we have done considerable work on the inheritance of these characters and hope to publish these results, it appears better to present in the present bulletin the correlations between characters as we find them in large populations, with very little reference to heredity. We do this because, with our material, as is very general in the quantitative study of inheritance in plants, the question of the precision of the results is complicated by the fewness of parents relative to the number of offspring, as well as by the rather stringent selection of parents. We think it expedient to defer to a later bulletin the treatment of these difficulties. Further, it is important to know these correlations before attempting a study of inheritance or of the correlation between characters in parent ears and yield.

In the comparison of two statistical results, the difference between the two results compared to its probable error is of great value. In general, we may take the probable error in a difference to be the square root of the sum of the squares of the probable errors of the two results. If the difference does not exceed two or three times the probable error thus obtained, the difference may reasonably be attributed to random sampling. If the difference between the two results is as much as 5 to 10 times the probable error, the probabilty of such differences in random sampling is so small that we are justified in saying that the difference is significant. In fact, a difference of ten times its probable error is certainly significant in so far as there is certainty in human affairs.

Such significant differences in our applications may perhaps be well divided into three classes:

(1) Those due to differences in variety of corn.
(2) Those due to seasonal influences.
(3) Those due to difference in soil treatment.
(4) Those to be attributed to selection of parents.

10. Source of material.—The material for this study is furnished by the crops obtained from a number of the regular experiment plots which are being conducted for different purposes. These plots may be considered as belonging to two different groups, one of which is devoted primarily to soil investigation and the other to experiments in corn breeding.

The soil plots comprise what are designated as the 400 and 500 series. They are devoted to a two-year rotation consisting of corn alternating with oats, that is to say, corn occupies the 400 series one year and the 500 series the next year.

Each series is divided into ten plots of one-tenth acre numbered from 401 to 410 and from 501 to 510. To these plots various soil treatments have been applied as follows:

401 and 501—None (check plot).
402 " 502—Legume catch-crop and crop residues.*

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*Corn stalks and oat straw plowed under, removing only the grain from the land.

403 and 503—Farm manure.
404 “ 504—Legume and crop residues and lime.
405 “ 505—Manure and lime.
406 “ 506—Legume and crop residues, lime and phosphorus.
407 “ 507—Manure, lime and phosphorus.
408 “ 508—Legume and crop residues, lime, phosphorus and potassium.
409 “ 509—Manure, lime, phosphorus and potassium.
410 “ 510—Legume and crop residues with extra heavy manure and phosphorus.*

The yields from these variously treated plots are given in the following tables in connection with the other data.

This brief description will serve to explain in a general way the significance of the various plots and the following data pertaining to them. The reader who may be interested in a more detailed account regarding the arrangement, description and history of these soil plots is referred to Bulletin 125 of this Station,—"Thirty Years of Crop Rotations on the Common Prairie Soils of Illinois," where are given the complete records.

The particular variety of corn grown upon these plots has been two strains of Leaming which have been under selection for a number of years for high-protein and low-protein content respectively, the work being controlled by the method of "mechanical selection" described in Bulletins 55-87-100.

To be more definite, in 1907, 1909, seed corn low in protein content was planted, while in 1908, seed corn high in protein was planted on the 400 and 500 series concerned in this investigation.

Although a material difference in composition between the two strains has been effected through this method of selection, this difference does not seem to have significantly affected the correlation values under consideration, as will appear from the results of this bulletin.

The corn breeding plots from which samples have been taken for these correlation studies represent four lines of selection which have been under way since 1896, the object in view being to change the normal composition of the grain of a variety of corn by producing strains of special chemical characteristics.

In this manner four strains of markedly different chemical composition have arisen from a single variety by selecting continuously for

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*Five times the ordinary application of manure and of phosphorus.

1—High-protein content
2—Low-protein content
3—High-oil content
4—Low-oil content.

For the history and the results of the first ten generations of this work the reader is referred to Bulletin 128, "Ten Generations of Corn Breeding." The variety under experiment contained originally in 1896 an average of 10.92 percent of protein and 4.70 percent of oil.

The composition of the different strains for the years herein concerned is as follows:

	High Protein.	Low Protein.	High Oil.	Low Oil.
1907	13.89	7.32	7.43	2.59
1908	13.94	8.96	7.19	2.39
1909	13.41	7.65	6.96	2.35

II. **Discussion of results.**—With a set of the four characters under consideration, there are possible six pairs of variates between each pair of which we can determine the correlation. From the results of the tables, it will be observed that we have carried out the determination of the correlation coefficient for some plots for each of these six pairs of characters. As the correlations coefficients we have determined and given in this paper seem sufficient to give a good general notion as to the value of correlations between these characters, it has appeared as well to defer further calculations of correlation coefficients until we ascertain whether further special determinations will be of service in problems of inheritance of these characters and their correlations with yield,—the problems to which we regard the present investigation as preliminary. The accompanying tables include the results of 141 determinations of correlation.

Two year rotation corn.—In length and circumference, the correlation centers about 0.33 for the year 1907, 0.47 for 1908, and 0.49 for 1909. For the three years together, the values center about 0.43. The smallest correlation is given by data from plot 409 of 1907. This correlation is 0.203. The greatest correlation is 0.623 furnished by data of plot 402 in 1909. These extreme values are very different as seen by comparison with their probable errors. They belong to different years, and the value 0.623 corresponds to a decidedly low yield while 0.203 corresponds to a high yield. In fact, there seems to be a somewhat general tendency towards high correlation of length and circumference when the yield is low and vice versa. There are three small values of correlation between length and circumference. These belong to three consecutive plots of 1907. Inspection of the correlation table shows that, in these cases, there is considerable deviation from linear regression—the ears of extremely large circumference tended to be shorter than ears of less extreme circumference.

In length and number of rows, the correlations are insignificant except possibly in one case where r is more than four times its probable error.

In circumference and rows, the correlation centers about 0.486 in the year 1907, 0.499 in 1908, 0.467 in 1909. The extremes presented are 0.425 and 0.608, which do not differ so much as the extremes for length and circumference. While the deviations are too great to be assigned to random sampling, it appears that there is both a difference in season, soil, and parentage.

In length and weight of ears, the mean value of the correlation is 0.810 in 1909, and these correlations did not show very great differences for different plots. We may regard 0.8 as sort of rough value for this correlation.

In weight and rows of kernels, we have values from 0.178 to 0.345. In weight and circumference, we have values from 0.648 to 0.840.

The Illinois Corn.—In length and circumference, the correlation are very different for selected strains. The conditions are complicated by differences of soil, and season. The low oil plot of 1907 gives the lowest correlation, whereas the low oil plot of 1908 gives the highest correlation of the entire series.

In correlation between circumferences and rows of kernels, there are much smaller differences between plots than for length and circumference.

Between length and rows of kernels, there appears to be no significant correlation, except possibly in one case.

Between length and weight, the correlations are not very different, and fall roughly between 0.65 and 0.85.

Arranging the pairs of systems of variates in descending order as to correlation, we have the following order:

(1) Length and weight.
(2) Circumference and weight.
(3) Circumference and rows of kernels.
(4) Length and circumference.
(5) Weight and rows of kernels.
(6) Length and rows of kernels.

For this arrangement the odds are pretty large except in the case of (3) and (4), and possibly (1) and (2). As a sort of general conclusion, we may say that the correlations between length-weight and circumference-weight are high. The correlations of circumference-rows of kernels, and length-circumference are considerable. The correlation of weight-rows of kernels is low, while that of length-rows is probably insignificant.

These correlations mean that the tendency towards a relative proportioning of length and circumference; and circumference and rows of kernels is considerably greater than that towards a relative proportioning of weight and rows of kernels or length and rows of kernels.

It seems somewhat disappointing that the correlation coefficients differ so widely, as this fact complicates the problem of assessing the influence of the selection of parents in a precise measure of heredity. The wide difference for different pairs of characters may be compared with the correlations between different pairs of characters of the human body, where it has been found that between measurement of the long bones of the arms and legs a high correlation exists, while between different measurement of the skull a much lower correlation exists.*

TABLE 1.—CORRELATION AMONG CERTAIN CHARACTERS OF EARS OF CORN 400 SERIES. CROP 1907. SEED: LOW PROTEIN BY MECHANICAL SELECTION

	Yield †	Value of r for length and circumference	Value of r for length and rows	Value of r for circumference and rows
401	68.4	0.423±0.019	--0.044±0.024	0.501±0.019
402	69.9	0.438±0.019	+0.007±0.024	0.446±0.020
403	69.4	0.312±0.020		0.484±0.018
404	75.9	0.462±0.018		0.548±0.017
405	66.6	0.452±0.018		0.502±0.019
406	84.6	0.403±0.019		0.470±0.018
407	68.6	0.282±0.021		0.440±0.020
408	84.1	0.278±0.021		0.554±0.016
409	71.4	0.203±0.021		0.487±0.019
410	95.6	0.411±0.017		0.432±0.018
		Value of r for length and weight	Value of r for rows and weight	Value of r for weight and circumference
401		0.781±0.008	0.275±0.023	0.768±0.009
405		0.786±0.009	0.223±0.024	0.721±0.011

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*Biometrika, Vol. 1, pp. 408-467.

†Computed at 80 lb. per bushel of ear corn.

TABLE 2.—CORRELATION AMONG CERTAIN CHARACTERS OF EARS OF CORN 500 SERIES. CROP 1908. SEED: HIGH PROTEIN BY MECHANICAL SELECTION

	Yield *	Value of r for length and circumference	Value of r for length and rows	Value of r for circumference and rows
501	37.5	0.590±0.014	0.090±0.025	0.514±0.019
502	45.0	0.528±0.015	0.061±0.026	0.506±0.019
503	33.1	0.562±0.015	0.120±0.027	0.432±0.022
504	39.3	0.526±0.016		0.486±0.021
505	39.6	0.519±0.016		0.608±0.017
506	76.1	0.422±0.015		0.480±0.016
507	46.1	0.385±0.018		0.444±0.020
508	74.1	0.360±0.016		0.517±0.016
509	39.8	0.444±0.017		0.508±0.019
510	75.0	0.344±0.017		0.497±0.015

		Value of r for length and weight	Value of r for rows and weights	Value of r for weight and circumference
501		0.855±0.006	0.345±0.021	0.771±0.009
505		0.871±0.005	0.348±0.021	0.763±0.009

* Computed at 80 lb. per bushel of ear corn.

TABLE 3.—CORRELATION AMONG CERTAIN CHARACTERS OF EARS OF CORN 4 0 SERIES. CROP 1909. SEED: LOW PROTEIN BY MECHANICAL SELECTION

	Yield *	Value of r for length and circumference	Value of r for length and rows	Value of r for circumferences and rows
401	46.2	0.548±0.016	0.004±0.027	0.452±0.021
402	38.6	0.623±0.016	0.027±0.034	0.466±0.026
403	48.4	0.453±0.118	-0.044±0.026	0.514±0.022
404	43.6	0.534±0.016		0.463±0.022
405	47.2	0.461±0.018		0.487±0.022
406	57.6	0.506±0.017		0.482±0.019
407	46.0	0.443±0.019		0.524±0.020
408	58.8	0.432±0.018		0.428±0.021
409	51.6	0.409±0.019		0.458±0.022
410	72.6	0.539±0.012		0.425±0.018

TABLE 3.—*Concluded.*

		Value of r for length and weight	Value of r for weight and rows	Value of r for weight and circumference
401		0.818±0.008	0.216±0.025	0.840±0.007
402		0.844±0.008	0.225±0.032	0.746±0.012
403		0.815±0.008	0.178±0.027	0.648±0.013
404		0.801±0.010	0.212±0.029	0.757±0.012
405		0.810±0.008	0.229±0.027	0.728±0.011
406		0.791±0.008		
407		0.800±0.008		
408		0.798±0.008		
409		0.785±0.008		
410		0.843±0.005		

* Computed at 50 lb. per bushel.—Shelled corn (dry substance).

TABLE 4.—CORRELATION AMONG CERTAIN CHARACTERS OF EARS OF CORN ILLINOIS CORN. CROPS 1907, 1908, 1909

	Value of r for length and circumference	Value of r for circumference and rows	Value of r for length and rows	Value of r for length and weight
Crop 1907				
High protein	0.202±0.031	0.490±0.026	−0.051±0.032	0.822±0.013
Low proein	0.368±0.028	0.520±0.025	−0.017±0.034	0.725±0.016
High oil	0.317±0.029	0.431±0.027		0.838±0.009
Low oil	0.128±0.035	0.562±0.024		0.727±0.017
Crop 1908				
High protein	0.310±0.027	0.435±0.025	−0.106±0.030	0.776±0.012
Low protein	0.293±0.027	0.488±0.024	−0.017±0.031	0.809±0.012
High oil	0.132±0.027	0.464±0.022		0.673±0.015
Low oil	0.569±0.020	0.459±0.025		0.868±0.007
Crop 1909				
High protein	0.183±0.030	0.592±0.021	−0.081±0.035	0.681±0.016
Low protein	0.437±0.022	0.305±0.029		0.770±0.011
High oil	0.299±0.025	0.335±0.026		0.769±0.013
Low oil	0.255±0.024	0.480±0.020		0.675±0.014

APPENDIX ON THE MATHEMATICAL THEORY OF CORRELATION.

1. **Mathematical function.**—A variable y is said to be a mathematical *function* of a variable x if they are so related that to assigned values of x there correspond definite values of y. Thus, if $y=2x+4$, y is a function of x; since, for any assigned value of x, we can compute y. Those who are familiar with analytic geometry know that a curve is useful for representing and following the variations of a mathematical function.

We shall assume, in the present treatment of correlation, a knowledge* of the use of a system of co-ordinate axes to represent numbers and functions.

In order to place the notion of correlation on a precise basis, we lay down the following special

2. **Definition.**†—*Two measurable characters of an individual or of related individuals are said to be correlated if to a selected series of sizes of the one there correspond sizes of the other whose mean values are functions of the selected values.* The word "sizes" is used in the sense of numerical measure, and the function is to be different from zero for some of the selected values.

To be concrete, we may think, for example, of measuring the correlation between length and circumference of ears of corn, or the correlation of fathers and sons with respect to stature.

To render the above definition in symbolic language and to develop the methods of determining the function mentioned in the definition are the first points in the application of mathematics to the theory of correlation. For this purpose, let x and y be variables such that $y=f(x)$ gives the mean value of a system of variates which correspond to a selected x. Suppose the following system of corresponding values results from measurement: (x', y'), (x'', y''), . . . , $(x^{(n)}, y^{(n)})$, where n is a large number indicating the total number of pairs observed. These observations are said to form a total population or universe of observations. As it is more convenient to deal with the deviations of the observations from their mean values than with the observations themselves, let (x_1, y_1), (x_2, y_2), . . ., (x_n, y_n) represent the deviations of the observations from their mean values. These deviations may be conveniently represented with respect to co-ordinate axes (Fig. 5). The origin then represents the mean of the two characters. In fact, we may think of the co-ordinate axes as passing through the mean of the table and drawn parallel to arrays. The vertical parallel lines of the figure may then be looked upon as separating the observations into arrays. The values of the y's which correspond to a given class mark x are said to form a y-array. Suppose there are s such arrays.

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*See Davenport's Principles of Breeding, pp. 687, 689.

†*Philosophical Transactions of the Royal Society,* Vol. 187A, pp. 256-257.

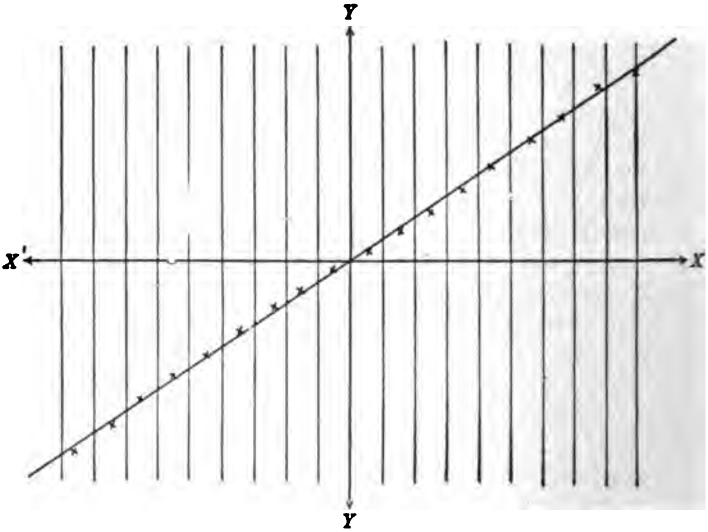

FIG. 5.

Let the crosses (×) in Fig. 5 represent the means of the y's in each of the s-arrays. If correlation exists, these means do not lie at random over the field, but arrange themselves more or less in the form of a smooth curve called the "curve of regression." This curve is a crude picture of the function which defines the correlation of the y-character relative to the x-character. Experience has shown that, in many sets of measurements, this line is approximately a straight line. For this reason, and for simplicity, the line subjected to the condition that the sum of the squares of the deviations (measured parallel to the y-axis and weighted with number of points in array) of the means from it shall be a minimum, is called the "line of regression." When the means lie exactly on the line, the regression is said to be "truly linear."

Let $y=mx+b$ be the function which represents the line of regression, then the problem of determining the line is that of determining m and b by means of the above minimal condition. The algebraic details of subjecting a line to this minimal condition are well known to those familiar with the method of least squares or the method of moments. The equation of the resulting line is

$$y = r\frac{\sigma_y}{\sigma_x}x \text{ , - - - - (1)}$$

where σ_x is the standard deviation of the population with respect to the x-character, σ_y is the standard deviation with respect to the y-character, and r is the correlation coefficient given by

$$r = \frac{\sum x y}{n\sigma_x \sigma_y} \text{ ,}$$

where the summation is extended to every pair of corresponding variates of the population. Similarly, the regression of the x character on the y character is given by

$$x = r\frac{\sigma_x}{\sigma_y} y \text{ - - - - (2)}$$

It should be noted that (2) cannot be obtained by solving (1) for x, for the reason that the correspondence is one between selected values and means.

3. **Standard deviation of arrays.**—Suppose that regression is truly linear, so that the means of the y-arrays fall on the line $y = r\frac{\sigma_y}{\sigma_x} x$; and, for the present, assume that the standard deviations of arrays are equal. Then the standard deviation of an array is given by

$$\frac{\sum\left(y - r\frac{\sigma_y}{\sigma_x}x\right)^2}{n} \text{ ,}$$

where the summation extends to the entire population.

$$\frac{\sum\left(y - r\frac{\sigma_y}{\sigma_x}x\right)^2}{n} = \frac{\sum y^2}{n} - \frac{2\sigma_y}{\sigma_x} r \frac{\sum x y}{n} + \frac{r\sigma_y^2}{\sigma_x^2}\frac{\sum x^2}{n}$$

$$= \sigma_y^2 - 2r^2\sigma_y^2 + r^2\sigma_y^2$$

$$= \sigma_y^2(1 - r^2) \text{ - - - - (3)}$$

Hence, the standard deviation of a y-array is obtained from the standard deviation σ_y by multiplying σ_y by $\sqrt{1-r^2}$.

If the standard deviations of parallel arrays are unequal, then $\sigma_y\sqrt{1-r^2}$ is simply sort of an average value for the standard deviation of an array.

Since the first member of (3) is a sum of squares divided by n, the second member must be positive. Hence $-1 \overline{\underset{<}{}} r \overline{\underset{<}{}} 1$.

This proves that the correlation coefficient takes values not greater than +1 nor less than —1.

Equation (3) shows further that if r=+1 all the individual points plotted from observations must lie on the line of regression, and we can in this case, when one character is given, tell exactly the magnitude of the associated character. Further, the ratio

$$\frac{x_1}{y_1} = \frac{x_2}{y_2} = \; . \; . \; . \; = \frac{x_n}{y_n} = \text{a positive constant.}$$

Similarly, if r=—1, the individual points plotted all lie on the line of regression, but

$$\frac{x_1}{y_1} = \frac{x_2}{y_2} = \; . \; . \; . \; = \frac{x_n}{y_n} = \text{a negative constant.}$$

4. **Correlations among three or more characters.**—The theory of correlation can be extended to apply to any number of variables. However, the complexity of the algebraic expression for any number,—say n-variables—becomes so great that it does not seem well to present a more extended discussion here, except to say that the final result is expressed in standard deviations and correlation between systems of variates in sets of two, so that the problem is capable of reduction to the one which we have solved.

For the general case, the reader with considerable mathematical training is refered to the treatment by Karl Pearson in the Philosophical Transactions of the Royal Society, A, 187, 1896, and A, 200, 1903.

5. **Correlation surfaces.**—If our frequency distributions follow normal probability curves (Bulletin 119, pp. 30-31) there can be derived a surface

$$z = f(x, y)$$

such that f (x, y,) h. k gives, to within deviations due to random sampling, the number of the population with corresponding measurements in the region bounded by x=x, y=y, x=x+h, y=y+k, where the x and y are deviations from mean values and h and k are any small numbers. For a considerable range of statistical data, this surface takes the form

$$z = \frac{n}{2\pi\sigma_x\sigma_y\sqrt{1-r^2}}\,e^{-\frac{1}{2(1-r^2)}\left[\frac{x^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}-2r\frac{xy}{\sigma_x\sigma_y}\right]},$$

where e is the base of natural logarithms and the other symbols have been defined above. The symbol π equals 3.1416, the ratio of circumference to a diameter in the circle.

As the only parameters in this surface (aside from the total number n) are the standard deviations and the correlation coefficient, we have in the standard deviations and its correlation coefficient a perfect description of a normally distributed population. This fact adds much to the significance of r as a measure of correlation.

6. **Formula for the correlation coefficient r which are better adapted to numerical calculation.**—In the first place, the calculation of the means and standard deviation of both systems of variates should be done by the shorter method presented on pp. 9-11, Bulletin 119.

It may be well to give that method here in a more symbolic form to prepare the way for the modified formula for r adapted to calculation.

Let G represent a guess at the mean M given by

$$M = \frac{f_1 v_1 + f_2 v_2 + \cdots + f_s v_s}{f_1 + f_2 + \cdots + f_s}, \qquad \text{- - - (1)}$$

where the class marks and f's are corresponding frequencies. Also let c be the correction to the guess G which gives M. That is

$$M = G + c,$$

$$c = M - G = \frac{f_1 v_1 + f_2 v_2 + \cdots + f_s v_s}{f_1 + f_2 + \cdots + f_s} - G.$$

$$c = \frac{f_1(v_1 - G) + f_2(v_2 - G) + \cdots + f_s(v_s - G)}{f_1 + f_2 + \cdots + f_s} \qquad \text{- - - - (2)}$$

Formula (2) gives the practical method of finding the correction to be applied to the guess to get the mean.

Next, the standard deviation is given by

$$\sigma^2 = \frac{f_1(v_1 - M)^2 + f_2(v_2 - M)^2 + \cdots + f_s(v_s - M)^2}{f_1 + f_2 + \cdots + f_s},$$

$$= \frac{f_1(v_1 - G - c)^2 + f_2(v_2 - G - c)^2 + \cdots + f_s(v - G - c)^2}{f_1 + f_2 + \cdots + f_s},$$

$$= \frac{\Sigma f_t\,(v_t - G)^2 - 2c\,\Sigma f_t\,(v_t - G) + c^2\,\Sigma f_t}{\Sigma f_t},$$

$$= \frac{\Sigma f_t\,(v_t - G)^2 - 2c\,\Sigma f_t\,(v_t - M + c) + c^2\,\Sigma f_t}{\Sigma f_t},$$

$$= \frac{\Sigma f_t\,(v_t - G)^2}{\Sigma f_t} - c^2 \quad \text{- - - -} \quad (3)$$

Formula (3) gives the practical method of calculating the standard deviation.

The value of r is given by

$$r = \frac{\Sigma x y}{n\,\sigma_x\,\sigma_y},$$

where x and y represent deviations from the means, and the summation extends to every pair of corresponding variates.

Let G_x and G_y represent class marks near the means of the systems of variates indicated by subscripts, and C_x, C_y corrections to these class marks which give the correct mean values so that

$$M_x = G_x + C_x,$$

$$M_y = G_y + C_y.$$

Let x′, y′ be deviations from G_x and G_y which correspond to deviations x, y from the mean. Then

$$x = x' - C_x,$$

$$y = y' - C_y.$$

$$r = \frac{\Sigma\,(x' - C_x)\,(y' - C_y)}{n\,\sigma_x\,\sigma_y},$$

$$= \frac{\Sigma x' y' - C_y\,\Sigma x' - C_x\,\Sigma y' + \Sigma\,C_x\,C_y}{n\,\sigma_x\,\sigma_y},$$

$$= \frac{\Sigma x' y' - C_y\,\Sigma\,(x + C_x) - C_x\,\Sigma\,(y + C_y) + \Sigma\,C_x\,C_y}{n\,\sigma_x\,\sigma_y},$$

$$= \left(\frac{\Sigma x' y'}{n} - C_x\,C_y\right)\frac{1}{\sigma_x\,\sigma_y}.$$

This is a formula whose computation is shown on pp. 297-301.

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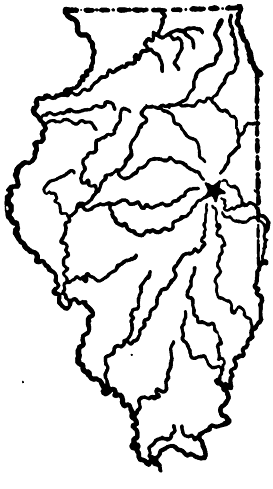
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 148—ABSTRACT

ON THE MEASUREMENT OF CORRELATION WITH SPECIAL REFERENCE TO SOME CHARACTERS OF INDIAN CORN

By HENRY L. RIETZ AND LOUIE H. SMITH



URBANA, ILLINOIS, NOVEMBER, 1910

The Station.

The bulletin is a ~~technical presentation~~ of the methods of determining the correlation coefficient for associated characters, together with considerable tabular matter giving the correlations for various strains of Indian corn. It is the purpose of this abstract to present the leading thought of the bulletin devoid of technical terms, and, omitting all reference to methods of calculation, to discuss briefly the meaning of the correlation coefficient, present the data involved, and assist the non-mathematical reader to an understanding of its significance. Anyone desiring to pursue the subject farther, particularly as to methods of calculation of the correlation coefficient, can secure the complete text upon request to the Agricultural Experiment Station.

Any one, who has at all considered the matter, is conscious that there is correlation of some characters, both in animals and plants. That is to say, that the different characteristics that go to make up the individual animal or plant do not exist independently of one another, but on the contrary are more or less corelated, or bound together by such physiological bonds as compel them to move more or less with reference to each other.

Among those who have not studied the matter carefully, but rely merely upon personal impressions derived from unsystematic observation, it appears that a notion prevails pretty commonly that characters are either perfectly correlated or entirely uncorrelated, the conception being that the characters are either absolutely bound together or else they move with complete independence. The truth is, however, that characters are seldom perfectly correlated, just as they are seldom independent. The mathematician follows accurate methods in determining precisely what correlations exist between characters in large populations. He has no method of determining the bond between two or more characters from a single or even a few individuals. He deals only with large numbers, and by his methods, he is able to distinguish very clearly whether, in general, two characters tend to move together or in opposition to each other, and approximately to what extent. If they move together, correlation is said to be positive. If they move in opposite directions, the one tending to increase proportionately as the other decreases, the correlation is said to be negative.

The present bulletin treats the precise methods of measuring this correlation. It is measured by a single number called the correlation coefficient, denoted by r, which may take values from -1 to 1, depending on how fluctuations in the two characters take place. If, in general, the characters fluctuate together, say either above or below the type, the value of (r) lies between 0 and 1 depending upon how closely the characters are correlated. If, in general, two corresponding characters fluctuate in opposite directions, the correlation is between 0 and -1. The values $r = +1$, and -1, indicate respectively perfect positive correlation, and perfect negative correlation, while indifference of the characters to each others fluctuations leads to the value $r=0$ when very large numbers are used.

The general reader is not concerned with the methods by which these values are obtained. He is concerned only with the results, which are significant and extremely valuable, and which with a little practice become easily apprehended by the non-mathematical reader. But a single further word of introduction is necessary, and that has reference to the so-called probable error, a decimal always following the correlation coefficient, and preceded by the + or — sign. This probable error has no reference to mistakes which might be made in computation. It has reference to the fact that any value which may be determined would probably have been different if a larger number of individuals had been involved. For example, if it is desired to ascertain what is the weight of mature draft horses of a given breed, it could be obtained approximately by weighing 100 such horses. It could be ascertained with greater accuracy by weighing 1000 such horses, but there is no absolutely accurate way of determining the actual weight until every draft horse of that age in the world has been weighed. The so called probable error of a result is a number that enables us to set limits within which we may reasonably expect the result to be found if we should use larger numbers in establishing a result. For a more complete statement of the meaning and applicability of the probable error, see Bulletin 119 of this station.

The bulletin treats the correlations among four characters of ears of corn—length, circumference, weight, and number of rows of kernels. The practical bearing of such information, as is contained in the results, lies in the facts, (1) that in the selection of parents for one character, we should know how this tends to change other characters; (2) that the problem of the correlation of characters and yield requires, for its solution, in case of a selected parentage, a knowledge of the correlation of the characters among themselves in the general population from which parents are selected; (3) that the problems of inheritance of these characters requires a knowledge of these correlations.

The following tables give the correlation coefficients and probable error for a large number of determinations that have been made at the Agricultural Experiment Station, and if the reader will take the pains to compare the different correlation coefficients,

Table 1.—Correlation among Certain Characters of Ears of Corn 400 Series. Crop 1907. Seed: Low Protein by Mechanical Selection

	Yield *	Value of r for length and circumference	Value of r for length and rows	Value of r for circumference and rows
401	68.4	0.423±0.019	--0.044±0.024	0.501±0.019
402	69.9	0.438±0.019	+0.007±0.024	0.446±0.020
403	69.4	0.312±0.020		0.484±0.018
404	75.9	0.462±0.018		0.548±0.017
405	66.6	0.452±0.018		0.502±0.019
406	84.6	0.403±0.019		0.470±0.018
407	68.6	0.282±0.021		0.440±0.020
408	84.1	0.278±0.021		0.554±0.016
409	71.4	0.203±0.021		0.487±0.019
410	95.6	0.411±0.017		0.432±0.018

		Value of r for length and weight	Value of r for rows and weight	Value of r for weight and circumference
401		0.781±0.008	0.275±0.023	0.768±0.009
405		0.786±0.009	0.223±0.024	0.721±0.011

* Computed at 80 lb. per bushel of ear corn.

Table 2.—Correlation among Certain Characters of Ears of Corn 5 0 Series. Crop 1908. Seed: High Protein by Mechanical Selection

	Yield *	Value of r for length and circumference	Value of r for length and rows	Value of r for circumference and rows
501	37.5	0.590±0.014	0.090±0.025	0.514±0.019
502	45.0	0.528±0.015	0.061±0.026	0.506±0.019
503	33.1	0.562±0.015	0.120±0.027	0.432±0.022
504	39.3	0.526±0.016		0.486±0.021
505	39.6	0.519±0.016		0.608±0.017
506	76.1	0.422±0.015		0.480±0.016
507	46.1	0.385±0.018		0.444±0.020
508	74.1	0.360±0.016		0.517±0.016
509	39.8	0.444±0.017		0.528±0.019
510	75.0	0.344±0.017		0.497±0.015

		Value of r for length and weight	Value of r for rows and weights	Value of r for weight and circumference
501		0.855±0.006	0.345±0.021	0.771±0.009
505		0.871±0.005	0.348±0.021	0.763±0.009

* Computed at 80 lb. per bushel of ear corn.

TABLE 3.—CORRELATION AMONG CERTAIN CHARACTERS OF EARS OF CORN 400 SERIES. CROP 1909. SEED: LOW PROTEIN BY MECHANICAL SELECTION

	Yield *	Value of r for length and circumference	Value of r for length and rows	Value of r for circumferences and rows
401	46.2	0.548±0.016	0.004±0.027	0.452±0.021
402	38.6	0.623±0.016	0.027±0.034	0.466±0.026
403	48.4	0.453±0.118	—0.044±0.026	0.514±0.022
404	43.6	0.534±0.016		0.463±0.022
405	47.2	0.461±0.018		0.487±0.022
406	57.6	0.506±0.017		0.482±0.019
407	46.0	0.443±0.019		0.524±0.020
408	58.8	0.432±0.018		0.428±0.021
409	51.6	0.409±0.019		0.458±0.022
414	72.6	0.539±0.012		0.425±0.018

		Value of r for length and weight	Value of r for weight and rows	Value of r for weight and circumference
401		0.818±0.008	0.216±0.025	0.840±0.007
402		0.844±0.008	0.225±0.032	0.746±0.012
403		0.815±0.008	0.178±0.027	0.648±0.013
404		0.801±0.010	0.212±0.029	0.757±0.012
405		0.810±0.008	0.229±0.027	0.728±0.011
406		0.791±0.008		
407		0.800±0.008		
008		0.798±0.008		
409		0.785±0.008		
410		0.843±0.005		

* Computed at 50 lb. per bushel. Shelled corn (dry substance).

he will learn something of the way corn behaves under a variety of conditions.

The material for this study is furnished by the crops obtained from a number of the regular experiment plots that are being conducted for different purposes. These plots belong to two different groups, one of which is devoted primarily to soil investigation (Tables 1-3), and the other to experiments in corn breeding (Table 4).

The soil plots are designated as the 400 and 500 series. They are devoted to a two year rotation consisting of corn alternating with oats, that is to say, corn occupies the 400 series one year and the 500 series the next year. Each series is divided into ten plots, and various soil treatments are applied. For a detailed account of the arrangement and the soil treatment of these plots, the reader is referred to the bulletin of which this is an abstract, or to Bulletin 125 of this station.

TABLE 4.—CORRELATION AMONG CERTAIN CHARACTERS OF EARS OF CORN ILLINOIS CORN. CROPS 1907, 1908, 1909

	Value of r for length and circumference	Value of r for circumference and rows	Value of r for length and rows	Value of r for length and weight
Crop 1907				
High protein	0.202±0.031	0.490±0.026	—0.051±0.032	0.822±0.013
Low protein	0.368±0.028	0.520±0.025	—0.017±0.034	0.725±0.016
High oil	0.317±0.029	0.431±0.027		0.838±0.009
Low oil	0.128±0.035	0.562±0.024		0.727±0.017
Crop 1908				
High protein	0.310±0.027	0.435±0.025	—0.106±0.030	0.776±0.012
Low protein	0.293±0.027	0.488±0.024	—0.017±0.031	0.809±0.012
High oil	0 132±0.027	0.464±0 022		0.673±0.015
Low oil	0.569±0.020	0.459±0.025		0.868±0.007
Crop 1909				
High protein	0.183±0.030	0.592±0.021	—0.081±0 035	0.681±0.016
Low protein	0.437±0.022	0.305±0.029		0.770±0.011
High oil	0.299±0.025	0.335±0.026		0.769±0.013
Low oil	0.255±0.024	0.480±0.020		0.675±0.014

The variety of corn grown upon these plots has been two strains of Leaming which has been under selection for high protein and low protein content respectively. In 1907 and 1909 the seed corn planted was low in protein content while in 1908 it was high in protein.

The corn breeding plots from which the material for Table 4 was taken, represents four lines of selection that have been under way since 1896 for high protein content, low protein content, high oil content and low oil content.

With a set of four characters under consideration, there are six pairs of characters, between each pair of which the correlation can be determined. From the results of the tables, it will be observed that the correlations for some plots are given for each of these six pairs of characters. The tables include the results of 141 determinations of correlation, and should give a good general notion of the values of these correlations for the corn under consideration.

In Table 1 are given, correlations between length and circumference, length and number of rows, circumference and number of rows, length and weight, weight and rows of kernels, weight and circumference, for some plots of low protein corn, differently treated, crop of 1907. A careful study of this Table shows, first of all, a considerable tendency for length and circumference to move together, that is, for long ears to be large in circumference, but that this correlation varies greatly in the different plots, ranging all the way from 0.203 to 0.462. Second, there is practically no correlation between the length of ear and the number of rows it contains, that is to say, one is no index whatever to the other. Third, there is a fairly high positive correlation between circumference and the number of rows, which means that the large ears have in general more rows than the small ears. However, the correlation in no case approaches very near to 1.0, which means that the large ears have not only more rows than the smaller ones, but the kernels are larger. There is a high correlation for length-weight, and weight-circumference, but a rather low correlation between weight and rows of kernels.

In Table 2 are also shown ten plots of high protein corn, differently fertilized, crop of 1908. The same general traits are maintained as in the former table, excepting that the correlation runs somewhat higher between length and circumference; and, that there is perhaps a slight positive correlation between the length of the ear and the number of rows that it contains.

Table 3 exhibits the correlation for the same series as shown in Table 1, but for the crop of 1909, and a more complete list of correlations between length-weight, weight-number of rows, and weight-rows of kernels. In these later determinations, we find what we should now expect, namely, a high correlation between length and weight and between weight and circumference, and a rather low correlation between weight and the number of rows.

Table 4 exhibits certain correlations for the so called Illinois corn, which, as stated above, consists of four strains bred for chemical composition. A gross comparison of this table will show that the correlation in any two characters varies in the same strain of corn in different years as it does by different methods of treatment. For example, the correlation between length and circumference in high protein corn, crop of 1907, was 0.202. The next year it was 0.310, and the next, 0.183. The reader will be interested in making this same sort of comparison for other strains of corn and for other characters.

Arranging the pairs of characters in descending order as to correlation, we have the following order:

(1) Length and weight.
(2) Circumference and weight.
(3) Circumference and rows of kernels.
(4) Length and circumference.
(5) Weight and rows of kernels.
(6) Length and rows of kernels.

For this arrangement, the odds are pretty large except in the case of (3) and (4), and possibly of (1) and (2).

As a sort of general conclusion, we may say that correlations for length-weight and circumference-weight are high. The correlation for circumference-rows of kernels and length-circumference are fairly high. The correlation of weight-rows of kernels is low, while that of length-rows of kernels is probably, in general, insignificant.

V 4041

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN NO. 149—ABSTRACT

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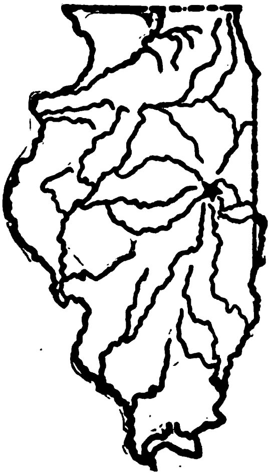
TUBERCULOSIS OF FARM ANIMALS

By CHAS. F. BRISCOE and W. J. MacNEAL



URBANA, ILLINOIS, FEBRUARY, 1911

SEP 1 1911
CAMBRIDGE, MASS.

TUBERCULOSIS OF FARM ANIMALS*

By CHAS. F. BRISCOE, Instructor in Botany, and W. J. MacNEAL, Assistant Chief in Bacteriology

Tuberculosis and the Tubercle Bacillus

1. Tuberculosis was known as early as 460 B. C. It is a disease due to a specific organism, *B. tuberculosis*. Four types of this organism are recognized; the human, bovine, avian, and a type belonging to cold blooded animals.

2. The disease is characterized by the formation of tubercles as a reaction of the animal tissues. The tubercle bacilli may enter the body thru the act of breathing, eating and thru wounds; and leave the body thru the mouth or nose, or in the milk, feces, urine, genital discharges, or discharges from wounds. The tuberculous animal rarely shows physical signs until the last stages of the disease.

3. In determining the presence or absence of tubercle bacilli in material supposed to be infectious, the method of animal inoculation is far superior to that of microscopical examination. This is true because of the difficulty of distinguishing the tubercle bacilli from other acid-fast bacilli, and the difficulty of finding them when present in small numbers.

Tubercle Bacilli in Butter and Oleomargarine

4. Tubercle bacilli are widely distributed in market butter. Table 1 shows a total of 1233 samples of butter tested of which 163, or 13.2 percent, were positive; Table 2 shows 209 samples of oleomargarine tested, with 9, or 4.3 percent, positive.

5. The percentage of samples containing tubercle bacilli shows no decrease when the work of the last few years is compared with the first work done twenty years ago.

6. Tubercle bacilli remain virulent in butter as ordinarily salted, for more than five months.

7. Two of six samples of butter tested at this laboratory contained tubercle bacilli virulent to guinea pigs.

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*The complete edition of the bulletin, of which this is a condensed outline, will be sent as long as available, upon request. Address Director, Agricultural Experiment Station, Urbana, Illinois.

TUBERCLE BACILLI IN MILK

8. There is recorded in the literature the testing of 7845 samples of market milk for tubercle bacilli of which 537, or 6.8 percent, contained this organism. In the United States three authors found tubercle bacilli present in 78, or 17.5 percent, in a total of 447 samples of milk tested, while in Continental Europe four authors found this organism present in 205, or 4.8 percent, of 4229 samples tested.

9. In 37 samples of market milk tested at this Station no tubercle bacilli were found.

10. Tubercle bacilli have been found in the milk from tuberculous cows with sound udders by many reliable investigators. These bacteria probably gained access to the milk from other sources (manure, urine, dust) than the interior of the udder, in most cases.

11. Tubercle bacilli are rarely excreted in the milk of tuberculous cows with sound udders, especially if the infection is localized; when the infection is generalized or when tubercle bacilli are *free in the blood,* these organisms may be excreted along with the milk.

12. Forty-seven samples of milk from ten tuberculous cows, tested at this laboratory, gave wholly negative results. None of the ten cows was found to be extensively tuberculous *post mortem.*

TUBERCLE BACILLI IN COW MANURE

13. Guinea pig inoculation tests are superior to microscopic tests in detecting the presence of tubercle bacilli in cow manure. By inoculation tests, tubercle bacilli in a suspension of fresh cow manure can be detected when present in an amount as small as one hundred billionth of a gram in the dose injected.

14. Ordinarily only a small percentage of tuberculous cattle are excreting virulent tubercle bacilli in their feces at any given time.

15. At this Station ninety-seven samples of feces from sixty-two cattle have been tested for tubercle bacilli by inoculation of guinea pigs. These organisms have been found four times in samples from three of the cows.

TUBERCLE BACILLI IN THE CIRCULATING BLOOD

16. At present the results of different investigators in detecting tubercle bacilli in the circulating blood are conflicting. This difference may be due to the amount of sample injected into the test animal; the larger the amount of sample, the larger the percentage of positive findings.

17. The contention of Rosenberger that tubercle bacilli are frequently found in the blood by microscopic test has not been confirmed by other workers.

18. As a diagnostic procedure the examination of the blood for tubercle bacilli is of little value.

19. Twelve samples of blood from eight cattle were tested for tubercle bacilli, both by the Rosenberger method and by guinea pig inoculations. No test showed the presence of these organisms.

PUBLIC HEALTH RELATIONS

20. There are about 200,000 deaths annually in the United States from tuberculosis, of which it is estimated (Park and Krumwiede) that 92 percent are caused by the human type of tubercle bacilli; and 8 percent, or 16,000 cases, are caused by the bovine type.

21. In the cases caused by the bovine type of tubercle bacilli the disease is probably contracted very largely thru the food and is found almost exclusively among children.

THE DISTRIBUTION OF BOVINE TUBERCULOSIS

22. Though our knowledge concerning distribution of cattle tuberculosis is yet incomplete, it is known to be extensive thruout the world; ranging from 10 to 48 percent where most testing has been done.

23. The two things most favoring the distribution of this disease are the extensive trade in (tuberculous) cattle, and the difficulty of recognizing the disease by physical signs until it is far advanced.

THE RESTRICTION OF BOVINE TUBERCULOSIS

24. The recognition of tuberculosis in cattle depends almost entirely upon the tuberculin test. The positive test is accurate in about 98 percent of the cases as shown by slaughter. The negative test is not so reliable.

25. The Bang method of handling a tuberculous herd is recommended to owners of large herds. The modified Bang method by means of a "Stock Owners' Association," is recommended to owners of smaller herds.

26. The responsibility of ridding farm animals of tuberculosis must finally be placed upon the stock owner. The State may well formulate rules and regulations, provide for free tuberculin testing, and for popular and special education upon the subject of animal tuberculosis.

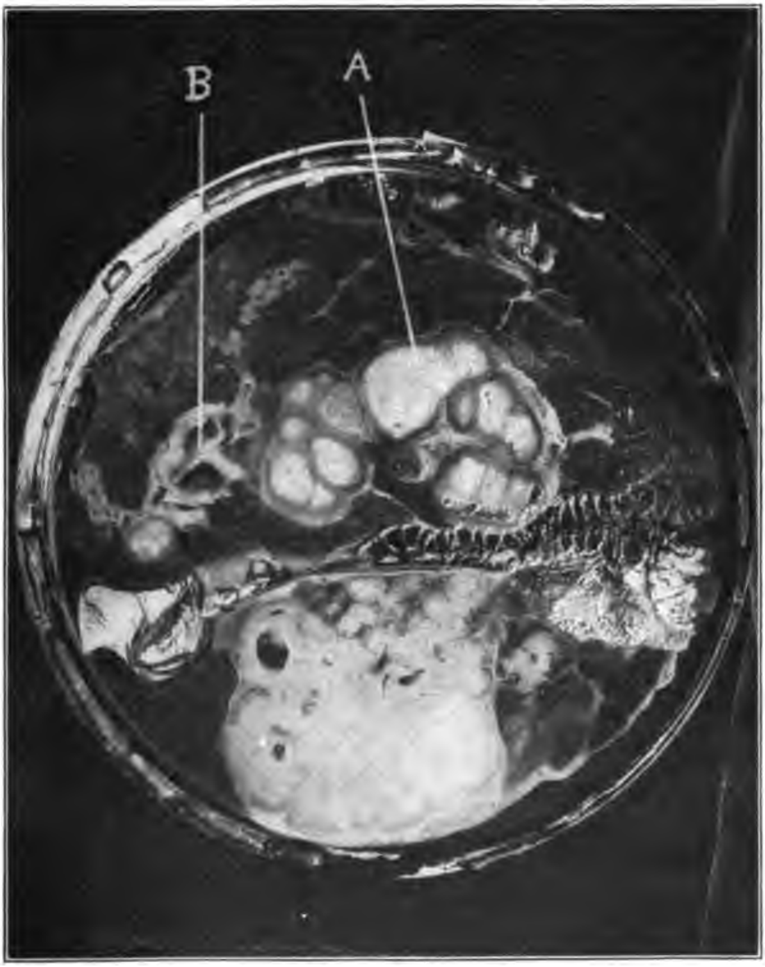
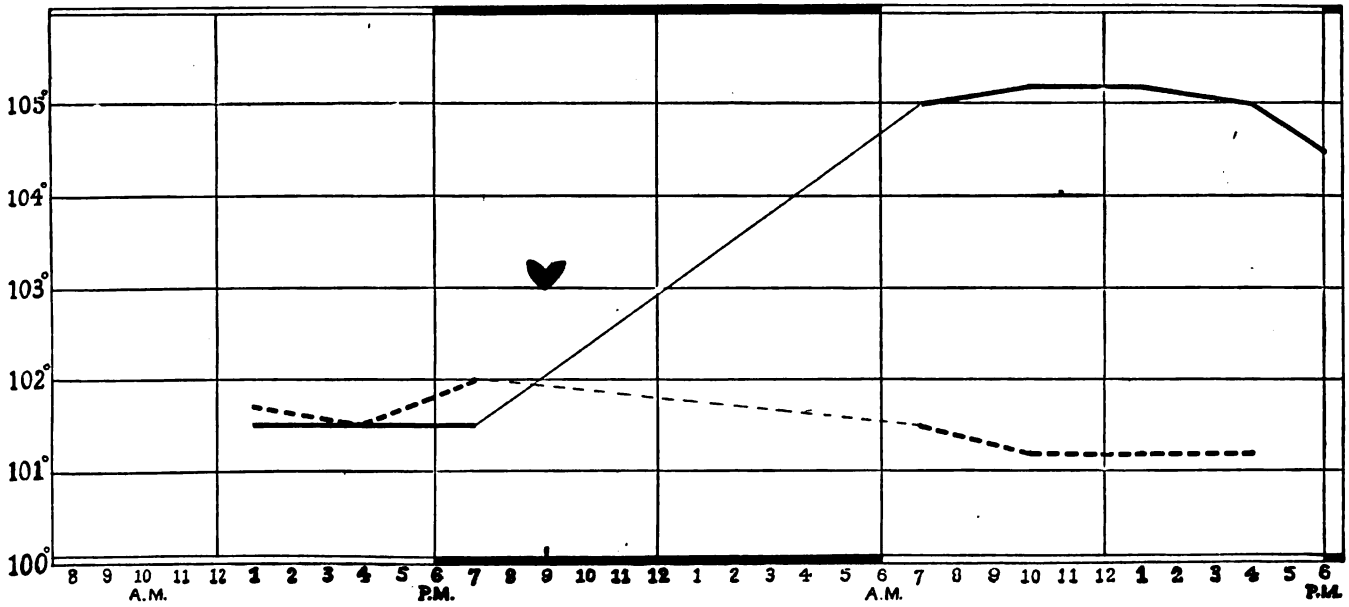
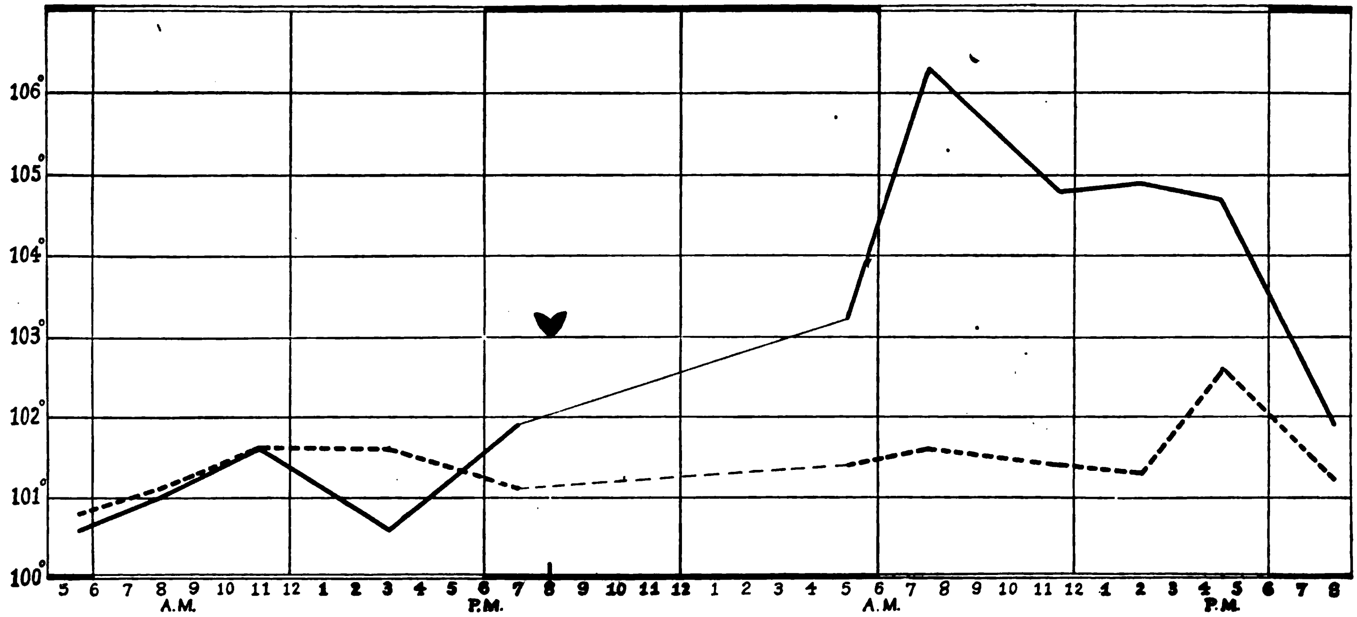


FIG. 1. SECTION THROUGH A PIECE OF LUNG FROM A COW, SHOWING CLOSED TUBERCULOSIS. ENCAPSULATED TUBERCLES AT A. BRONCHIAL TUBE AT B. NATURAL SIZE.



TUBERCULIN TEST. TIME OF INJECTION, 9 P. M.
POSITIVE REACTION (RED AND WHITE) ———
NEGATIVE REACTION (RED NO. 2) - - - - - - -

(Data from the records of the Illinois State Veterinarian, by courtesy of Dr. J. M. Wright.)



TUBERCULIN TEST. TIME OF INJECTION, 8 P. M.
POSITIVE REACTION (1004) ———
NEGATIVE REACTION (1015) - - - - -

(Data from the records of the Department of Dairy Husbandry, University of Illinois, by courtesy of Professor C. C. Hayden)

TEST OF DISEASED HERD, MAY, 1905
(From New York Agr. Exp. Sta. Bull. 279)

Animal	Breed	Age	Weight	Temperature before injection				Tuberculin injected 10:00 P. M.	Temperature after injection					Reaction
				10:30 A. M.	2:30 P. M.	4:00 P. M.	8:15 P. M.		7:00 A. M.	9:45 A. M.	11:00 A. M.	12:15 P. M.	3:15 P. M.	
Chloe	Mixed grade	6	1100	101.3	102.2	101.6	101.4	2.2cc.	103.4	105.2	104.3	102.5	101.8	+
Lady	Jersey	11	960	101.8	101.4	102.0	100.7	1.9cc.	102.3	104.0	104.7	104.1	102.7	+
Kate......	Jersey grade	6	900	101.4	101.6	101.3	100.7	1.8cc.	101.6	101.3	101.3	101.8	101.8	—
Millie D ...	Jersey	13	950	101.2	101.1	100.9	101.2	1.9cc.	101.6	101.8	101.6	101.2	101.9	—
Lily........	Jersey grade	6	800	100.6	100.9	101.6	100.6	1.6cc.	102.0	103.1	101.8	102.0	102.2	?

TUBERCULIN TEST CHART
(From records of the Illinois State Veterinarian, by courtesy of Dr. J. M. Wright)

Animal	Breed	Age	Weight	Temperature before injection				Tuberculin injected 9:00 P. M.	Temperature after injection					Reaction
					1:00 P. M.	4:00 P. M.	7:00 P. M.		7:00 A. M.	10:00 A. M.	1:00 P. M.	4:00 P. M.	6:00 P. M.	
Red and White	Mixed	6	1000		101.5	101.5	101.5	2 cc.	105.0	105.2	105.2	105.0	104.5	3.7° +
Roan	Mixed	8	1050		102.0	102.0	102.0	2 cc.	106.5	106.0	106.0	106.0	105.5	4.5° +
Red (1)......	Mixed	7	1050		102.0	102.0	102.0	2 cc.	102.0	101.5	101.5	101.5	......	—
Red (2)..	Mixed	6	950		101.7	101.5	102.0	2 cc.	101.5	101.2	101.2	101.2	.....	—

TUBERCULIN TEST CHART
(From records of the Dairy Department, University of Illinois, by courtesy of Professor C. C. Hayden)

Animal*	Age	Weight	Temperature before injection					Tuberculin injected 8:00 P. M.	Temperature after injection						Reaction
			5:30 A. M.	8:00 A. M.	11:00 A. M.	3:00 P. M.	7:00 P. M.		5:00 A. M.	7:30 A. M.	11:30 A. M.	2:00 P. M.	4:30 P. M.	8:00 P. M.	
1004	6	1100	100.6	101.0	101.6	100.6	101.9	2 cc.	103.2	106.3	104.8	104.9	104.7	101.9	+
1007	8	1250	101.3	101.0	101.2	102.0	101.2	2 cc.	104.3	105.3	105.7	106.3	105.2	102.2	+
1015	7	1100	100.8	101.1	101.6	101.6	101.1	2 cc.	101.4	101.6	101.4	101.3	102.6	101.2	—
1018	8	1019	100.8	100.9	101.5	102.1	100.8	2 cc.	101.2	101.6	101.3	101.3	102.2	101.7	—

*These animals were all grade Holsteins.

V4047

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BULLETIN NO. 150

FEEDING FARM WORK HORSES

By RUFUS C. OBRECHT

URBANA, ILLINOIS, AUGUST, 1911

Museum of Comp. Zool.
CAMBRIDGE, MASS.

SUMMARY OF BULLETIN NO. 150

OBJECT.—A comparison of clover and timothy hay for farm horses at work; effect of mixing ground grain with chaffed clover hay; comparison of alfalfa hay with clover and with timothy hay, respectively; comparison of corn and alfalfa hay with a mixture of corn, oats, bran, oil meal, timothy and alfalfa hay; effect of grinding corn and oats when fed with wheat bran, timothy and alfalfa hay. Page 433.

PLAN.—Ten teams of horses were used in the various tests. They were well-bred grade geldings, except one team of mares, with a predominance of Percheron blood. The initial weight per horse was from 1003 to 1560 pounds; but the horses in the experiment proper only varied from 1250 to 1420 pounds. In general the plan was to feed the two horses of each team, simultaneously, on the respective rations to be compared and then reverse the rations for an equal length of time to eliminate the influence of individual feeding capacity of the horses. Page 434.

CLOVER AND TIMOTHY HAY COMPARED.—But little difference was observed in the value of clover and timothy hay when fed in conjunction with corn, oats, oil meal and wheat bran, the difference being slightly in favor of clover. Page 437.

MIXING GRAIN WITH CHAFFED CLOVER.—The results show a slight saving due to mixing ground grain with chaffed clover hay, but not sufficient to justify the expense. Page 444.

CLOVER AND ALFALFA HAY COMPARED.—Horses fed alfalfa and timothy ate less grain and hay and gained slightly more in weight than those fed clover and timothy while doing the same amount of labor. Page 447.

ALFALFA AND TIMOTHY HAY COMPARED.—20 to 22 percent less grain was required to maintain the weight of horses fed alfalfa than those fed timothy hay. Page 449.

CORN AND ALFALFA HAY COMPARED WITH CORN, OATS, WHEAT BRAN, OIL MEAL, TIMOTHY AND ALFALFA HAY.—Horses fed corn and alfalfa ate 22 percent less grain than those fed the mixed ration, and lost 6 pounds more in weight per head in eight weeks. The ration of corn and alfalfa cost 6 cents less per horse per day than the mixed ration. Page 452.

GRINDING CORN AND OATS.—Horses fed ground corn and oats with wheat bran, oil meal, timothy and alfalfa hay consumed 9 percent less feed and gained 3 pounds more in weight per head in six weeks than those fed whole corn and oats with a similar ration. Page 455.

CONCLUSIONS. Page 457.

FEEDING FARM WORK HORSES

BY R. C. OBRECHT
ASSISTANT CHIEF IN HORSE HUSBANDRY

The problem of feeding work horses is one involving the economical production of energy, and maintenance of health. It is of considerable importance to know how much hay and how much grain a farm work horse at hard labor should receive in order that he may work with the greatest efficiency and economy. With high priced grains, it is very desirable to know the relative value of different roughages in order that economy may be practiced in making up a ration for work horses. In order to determine some of these points a number of experiments have been conducted at this Station in feeding College and Experiment Station horses used for teaming and field work.

OBJECT OF THESE EXPERIMENTS

The object of these experiments was to secure data for a comparison of rations for feeding farm work horses with respect to the following points: (1) maintenance of weight, (2) their health, spirit and ability to endure hard work, (3) economy of the ration.

In Bulletin 141, issued by this Station, it was shown that clover hay is greatly superior to timothy hay as the roughage part of a ration when fed in conjunction with corn and oats for fleshing horses for market. The question has been frequently asked regarding the relative merits of clover for feeding farm work horses. In order to throw some light upon this subject a test was made in which clover was compared with timothy hay.

PLAN

In the spring of 1908 a test was planned involving seven teams, whereby one horse in each team was to receive timothy hay, and the other clover hay. With but few exceptions each horse in the team worked an equal number of hours with his mate and at the same kind of labor. After three months one team became unfit for hard work, due to unsoundness of side-bones and spavins, and had to be discarded from the final results, thus leaving only six teams in the test. (Later three additional teams were used.)

The roughages used were choice timothy hay and choice clover hay. However, the timothy was of slightly better quality than the clover used, which was the best obtainable under local conditions. The clover hay (medium red variety) was of good quality and free from dust, but a little dark and contained some corn stalks. Each feed of hay was weighed to the horse and recorded and any refuse left was weighed back and deducted from the amount fed, which occurred more often with the horses receiving clover than those receiving timothy. The quantity of grain fed was left largely to the feeder's judgment, the amount being determined by the individuality of the horse, some receiving more than others. The grains fed were corn, oats, oil meal and bran. The corn was of good quality; the bran was of good grade, some from Minneapolis, and some from Kansas mills; the oil meal was old process pea size.

The test was divided into periods of four weeks each and extended over twelve periods, or 336 days. During the first seven periods one of the horses in each team was fed timothy and the other clover, while during the five remaining periods, the hay was reversed so that the horses first receiving timothy received clover and those receiving clover received timothy, thus checking any differences in the individuality of the horses.

All weights of the horses in this experiment both at the beginning and close of each period, were obtained by taking the average of three days' weights. The horses were weighed in the morning after receiving grain and hay but before watering, on the day previous to the close of the period or of the experiment as the case may be, the closing day and again the following day. During the hot weather a few of the teams received about two gallons of water in the morning before feeding and weighing, the quantity always being limited and the same amount given to each horse in the team. There is bound to be considerable fluctuation in the weight of horses from day to day owing to the amount of water consumed, the work done, and the amount of perspiration. Extreme cases show as much variation as seventy pounds on succeeding days under similar conditions of weighing.

One of the horses, No. 59, refused to eat oil meal and consequently it was omitted from his ration. This horse, apparently, was not in the best of health for he did not consume as much grain as he should have in order to maintain his weight. He appeared well but for some reason lacked appetite enough to consume relatively as much grain as the other horses. Each horse was branded with a number on his hoof as an identification mark and the records of the horses were taken by numbers rather than by names. The horses varied in age from four to nine years. With the exception of the one team above mentioned, all were sound and in good health and remained so thruout the experiment.

In recording the amount of work done it was graded as hard and medium labor. Hard labor involves such work as plowing, harrowing, working on the binder and mower and heavy teaming, such as hauling feed and manure. Medium labor involved such work as hauling manure over good roads, shelling corn, light cultivation, etc., some of which might be called hard labor by many teamsters. This division of labor is of course an arbitrary one for it is very difficult to say just where one stops and the other begins. In fact it is the total number of hours of labor that is of greatest importance. The work frequently required of the teams was such as would be done by three horses on most farms; for instance, plowing and working on a disc harrow or disc drill. However, the working hours were not so long. Ordinarily the teams were started to work at seven o'clock in the morning and worked until six at night with one hour for noon, with the exception of Saturdays when work usually stopped at five. During the winter months the work day was only nine hours.

THE HORSES

The horses were all well-bred grade geldings with the exception of one team, Nos. 51 and 52, which were mares. Most of them showed evidence of Percheron blood, tho some had more of the characteristics of the Shire and others of the Belgian. In selecting the horses an effort was made to get them as nearly uniform as possible in the team and with equal feeding qualities. They were all in good condition at the beginning of the experiment.

Two of the teams, Nos. 5 and 6, belonged to the Agronomy Department. These did the hardest work and most of it came during the spring and summer months, as most farm work does. Team No. 4 was owned by the Department of Dairy Husbandry. This team as well as the three teams owned and used by the Animal Husbandry Department, Nos. 1, 2 and 3, worked quite hard almost every work-day thruout the year. It frequently happened that the hauling of feed and manure over bad roads during the winter months was quite as hard as the farm work during the summer, with the exception of slightly shorter days.

In determining the cost of feeding the horses, the following prices for feeds were used:

Corn	50c per bushel
Oats	40c per bushel
Wheat bran	$20.00 per ton
Oil meal	$32.00 per ton
Clover hay	$10.00 per ton
Timothy hay	$12.00 per ton
Alfalfa hay	$16.00 per ton

TABLE 1.—TEAM NUMBER, HOOF NUMBER, LOT NUMBER, BREED, AGE, AND INITIAL WEIGHT OF HORSES USED IN THESE TESTS

Team	Hoof No.	Lot No.	Predominance of breed character	April 2, 1908	
				Age	Weight
1	51	1	Percheron	8	1379
	52	2	Percheron	7	1378
2	57	1	Shire	4	1395
	58	2	Percheron	4	1375
3	60	1	Shire Percheron	4	1292
	59	2	Percheron Shire	4	1292
4	64	1	Belgian	6	1338
	65	2	Belgian	7	1420
5	66	1	Percheron	7	1302
	67	2	Percheron	8	1250
6	69	1	Belgian Percheron	8	1393
	68	2	Percheron Belgian	9	1348
				March 27, 1909	
7	72	1	Percheron Shire	4	1309
	73	2	Shire	4	1303
8	74	1	Amer. Trotter	5	1251
	75	2	Amer. Trotter	5	1270
9	76	1	Amer. Trotter	6	1003
	77	2	Amer. Trotter	5	1094
				March 26, 1910	
10	79	1	Percheron	7	1560
	78	2	Percheron	7	1482

TABLE 2.—TEAM NUMBER, HOOF NUMBER, LOT NUMBER, KIND OF HAY FED, INITIAL AND FINAL WEIGHT AND GAIN OF HORSES

Team	Hoof No.	Lot No.	Kind of hay fed April 2 to Oct. 15, 1908	Weight		Gain or loss lbs.	Kind of hay fed Oct. 15, '08 to March 4, '09	Weight March 4	Gain or loss lb.
				April 2	Oct'r 15				
1	51	1	Timothy	1379	1386	7	Clover	1359	−27
	52	2	Clover	1378	1441	63	Timothy	1341	−100
2	57	1	Timothy	1395	1382	−17	Clover	1515	133
	58	2	Clover	1375	1380	5	Timothy	1555	175
3	60	1	Timothy	1292	1319	27	Clover	1377	58
	59	2	Clover	1292	1259	−33	Timothy	1239	−20
4	64	1	Timothy	1338	1338	00	Clover	1404	66
	65	2	Clover	1420	1374	−46	Timothy	1416	42
5	66	1	Timothy	1302	1318	16	Clover	1363	45
	67	2	Clover	1250	1317	67	Timothy	1289	−28
6	69	1	Timothy	1393	1399	6	Clover	1568	169
	68	2	Clover	1348	1405	57	Timothy	1408	3
Average		1	Timothy	1350	1357	7	Clover	1431	74
		2	Clover	1344	1363	19	Timothy	1375	12

From Table 1 it will be seen that the horses were fairly unform in size and age. Table 2 shows the kind of hay fed, the initial and closing weight and gains of the various horses during the first seven periods of the test and also during the last five periods when the hay was reversed. It will be noticed from this table that Lot 1 averaged six pounds heavier per horse at the beginning of the experiment than Lot 2 and made 12 pounds less gain per horse during the first seven periods when fed on timothy hay and 62 pounds more gain during the last five periods when fed on clover hay.

The average daily grain and hay by periods are grouped together in Tables 3 and 4, bringing out clearly the fact that the horses receiving clover hay consumed slightly less grain and hay during the first seven periods and made 12 pounds more gain per horse than those receiving timothy hay. When the hay was reversed, Lot 1 getting the clover, made 62 pounds more total gains per horse during the last five periods than those getting timothy hay, but it will be noticed that they were also getting 1.2 pounds more grain per day than the other lot. This seemingly large gain should be attributed in part to the greater amount of grain fed as well as to the influence of clover. During the first seven periods the horses receiving clover hay did the same amount of work as those receiving timothy hay and on less feed, but when the hay was reversed the gains decreased. The data indicates that there is but little difference in the value of clover and timothy hay when fed in conjunction with corn, oats, oil meal and bran, for feeding farm work horses at hard labor, the difference shown here being slightly in favor of clover. It should be definitely understood, however, that it is not the common practice to feed as great a variety or as near a balanced ration of concentrates as was used in this test. Had corn alone been used as the concentrate quite different results would be anticipated. In other words the roughage part of the ration is not of great importance when the grain fed approximates a well balanced ration.

All the horses in the test remained in good health thruout the experiment excepting No. 60, which was subject to an occasional attack of colic. There was no noticeable difference in the spirit or the ability of the horses to endure hot weather. The horses receiving the clover hay had glossier coats of hair, which is indicative of thrift. Their bowels were looser, but not to such an extent as to be objectionable for doing hard work. The teamsters were frequently asked as to the zest and ability of the horses for endurance, and they reported that no observable difference could be detected, altho most of them had been prejudiced in favor of timothy hay at the beginning. Many people are prejudiced against using clover hay as feed for horses fearing it will produce heaves. Heaves

TABLE 3.—SUMMARY LOT 1, AVERAGE PER HORSE BY PERIODS, AND GENERAL AVERAGE

PERIODS 1 TO 7 INCLUSIVE

4 week periods ending	Period	Average daily grain, lb.				Average daily timothy lb.	Average wt. at end of period, lb.	Gain or loss lb.	Total labor hours		Average daily labor work days, hours
		Corn	Oats	Oil meal	Bran				Hard	Medium	
April 30.......'08	1	6.77	6.77	.91	.52	15.41	1321	−29	155.	32.9	7 83
May 28. ....'08	2	6.77	6.77	.89	.85	15.71	1307	−14	139.2	26.0	6.7
June 25.......'08	3	7.62	7.62	.92	.715	16.07	1283	−24	190.0	20.	8.8
July 23. ......'08	4	7.98	7.98	.92	.57	16.05	1289	6	169.8	47.3	9.0
August 20.....'08	5	7.93	7.93	.92	.57	15.87	1295	6	139.8	68.7	8.7
September 17. '08	6	7.96	7.96	.92	.57	15.91	1334	39	126.3	69.0	8.1
October 15....'08	7	7.55	7.55	.92	.57	15.93	1357	23	98.	74.6	7.2
Total	....	52.58	52.58	6.40	4.36	110.95	....	7	1018.1	338.5	...
Average...... .	...	7.51	7.51	.91	.62	15.85	....	1	145.4	48.4	8.1

PERIODS 8 TO 12 INCLUSIVE

						Average daily clover					
November 12. .'08	8	7.52	7.52	.....	.57	15.85	1372	15	91.4	101.5	8.0
December 10. .'08	9	7.23	7.49	.....	.57	15.00	1391	19	71.8	91.7	6.8
January 7.....'09	10	5.91	7.39	.....	.57	15.14	1373	−18	96.0	69.6	6.9
February 4....'09	11	5.51	7.56	......	.57	15.28	1433	60	39.6	67.5	4 5
March 4.......'09	12	5.43	6.79	....	.66	15.72	1431	− 2	56.2	60.2	4.9
Total	....	31.60	36.75	....	2.94	76.99	....	74	355.0	390.5	...
Average. .	....	6.32	7.35	.....	.59	15.40	....	15	71.0	78.1	6.2

TABLE 4—SUMMARY LOT 2, AVERAGE PER HORSE BY PERIODS AND GENERAL AVERAGE

PERIODS 1 TO 7 INCLUSIVE

4 week periods ending	Period	Average daily grain, lb.				Average daily clover lb.	Average wt. at end of period, lb.	Gain or loss lb.	Total labor, hours		Average daily labor work days, hours
		Corn	Oats	Oil meal	Bran				Hard	Medium	
April 30........'08	1	6.52	6.52	.82	.49	15.17	1322	−22	155.5	33.3	7.87
May 28........'08	2	6.64	6.64	.79	.85	15.57	1305	−17.3	139.2	26.	6.7
June 25........'08	3	7.40	7.40	.79	.715	15.78	1294	−11	190.0	20.	8.8
July 23........'08	4	7.69	7.69	.79	.57	15.73	1297	3	169.8	47.3	9.0
August 20....'08	5	7.75	7.75	.79	.57	15.73	1305	8	139.8	68.7	8.7
September 17.'08	6	7.75	7.75	.79	.57	15.93	1346	41	126.3	66.8	8.0
October 15....'08	7	6.99	6.99	.79	.57	15.96	1363	17	98.	74.6	7.2
Total...........	....	50.74	50.74	5.56	4.33	109.87	....	19	1018.6	336.7	....
Average........	....	7.25	7.25	.79	.62	15.7	....	2.7	145.5	48.1	8.1

PERIODS 8 TO 12 INCLUSIVE

						Average daily timothy					
November 2...'08	8	6.82	6.82	......	.57	15.85	1351	−12	91.4	101.5	8.0
December 10..'08	9	6.60	6.89	......	.61	14.88	1349	− 2	71.8	91.5	6.8
January 7.....'09	10	5.41	6.76	......	.57	15.14	1326	−23	96.	69.6	6.9
February 4....'09	11	5.17	6.47	......	.57	15.28	1370	44	38.1	66.6	4.4
March 4.......'09	12	5.10	6.38	......	.57	15.55	1375	5	57.8	60.9	4.9+
Total...........	....	29.10	33.32	......	2.89	76.70	....	12	355.1	390.1	....
Average........	....	5.82	6.66	......	.58	15.34	....	2.4	71.02	78.02	6.2

is a digestive trouble and more likely to be produced with clover hay than with timothy due principally to the fact that clover is more palatable and consequently a horse is more likely to gorge himself with it when given all he will eat. Dusty hay is more likely to produce heaves than hay of good quality, and the danger from feeding it may be lessened by sprinkling it with lime water.

In arriving at the weight of a horse for a certain feeding period the average of the initial and closing weights were used. The weight of a horse being a variable quantity dependent upon the amount of flesh carried, should be taken in that flesh in which we wish to keep him when at work. In this test the average weight for the 12 periods was used and the grain and hay per 100 pounds live weight computed from this average.

METHODS OF FEEDING

Since the stomach of a horse is a comparatively small organ, the average size being only 3½ gallons while that of a cow, of which there are four compartments, has a capacity of 55 to 60 gallons, it will readily be seen that the horse is poorly adapted to consuming relatively large quantities of coarse feeds. Due to the large amount of crude fiber in hay it requires considerable energy for its digestion and also a much longer time than grains. In feeding the horses used in these tests the practice was adopted of giving the grain in approximately three equal feeds, fed morning, noon and night. The morning feed was given between 5 and 5:30, the noon feed at 12 and the evening feed at 6. As the horses began work at 7 o'clock in the morning, this gave them a full hour and one-half in which to consume and digest their feed before starting to work. One hour was taken for the noon feed. The hay was divided into three feeds; fully half and sometimes a little more was given in the evening, about one-fourth in the morning and a little less than one-fourth at noon. It is believed that much of the digestive troubles of horses are due to the over-feeding on roughages and putting them at work with a distended stomach after they have been allowed to gorge themselves with hay. It is a better plan to limit the hay during the morning and noon feed and give most of it at night when they have a long period of rest and plenty of time for its digestion.

On Saturday nights the regular grain feed was omitted during the first year and a four pound bran mash given in its stead. This was done in order to keep the horses' bowels in good condition, but when an occasional run on grass is given the bran is not necessary. On Sunday the noon feed of grain was omitted and an extra four pounds of hay was given in the morning to teams Nos. 1, 2 and 3. The other three teams received their regular noon feed of grain as usual on Sundays but no additional hay. During other idle days for whatever cause, after one day had elapsed, the grain was reduced to one-half the usual amount and continued for four days, when it was gradually increased again until the normal amount was given. When the horse was put to work he was put back immediately on his regular grain feed. This was done to prevent azoturia and it seems to be an efficient method.

During the time when a horse receives exercise he is expending energy and his system readily carries off the waste products, but during enforced idleness the system becomes much more sluggish especially when the horse is not accustomed to inactivity. For this reason he should not be fed a full amount of grain for he is not expending the energy he does when at work, or having exercise, and consequently the system is soon likely to become stagnant in not being able to free itself of the waste material. After the elapse of a short time the horse's system seems to readjust itself to its new mode of life, then there is not the danger from giving full feed of grain that there is when he is not accustomed to idleness.

Effect of Mingling Grain with Chaffed Hay

Every observant feeder has noticed that some horses pass a considerable quantity of undigested grain in their feces. Horses with ravenous appetites are more likely to do this than others, due to the fact that they do not chew and masticate their food thoroly before swallowing it and are given insufficient time for its digestion before being put at hard work. This is especially true when at hard work and large feeds of grain are given. In order to find a means of preventing this loss and also of maintaining the health of the horses it was decided to conduct a test where ground grain was mingled with chaffed hay for one horse, while the other in the teams received ground grain and the same kind of hay unchaffed, but the grain and hay were not mingled. As a preliminary study for this test it was observed that from an average of a number of trials conducted with the Experiment Station farm horses it required about thirteen minutes to consume five and one-half pounds of grain (equal quantities of ground oats and cracked corn) when thoroly dampened, twenty-seven minutes to consume the same quantity when fed dry, and about twenty-two minutes to consume the same quantity when fed whole and dry; the difference in time being due to the fact that ground oats and cracked corn fed dry require a longer time for thoroly mixing with saliva in preparation for swallowing.

In carrying out this test of feeding the ground grain mingled with chaffed hay, the entire morning and noon feeds of hay were chaffed and the grain was mingled with it. In most cases from three to four pounds of chaffed hay were fed in the morning and usually from two to three pounds of chaffed hay were given at noon and two pounds of chaffed hay in the evening, the remainder of the evening hay being fed whole. A like quantity of long hay was fed to the other lot of horses and the grain was ground and fed dry in the usual manner, not mixed with chaffed hay. It was thot that the chaffed hay would not be any more digestible or any more nutritious than the long hay except as it would cause a slower consumption of the grain and a more complete mastication of it. During a part of the time the grain mingled with the chaffed hay was slightly dampened to allay the dust and prevent it from being inhaled as well as to cause the grain and hay to adhere to each other. The dampening of the chaffed hay and grain was discontinued during the hot weather as some of the horses would not always thoroly clean up their feed at time of feeding and it would soon sour when left in the feed box. If the grain is mingled with enough chaffed hay there need be no danger of foundering horses from over-feeding as they will get so much crude fiber that they are not likely to over-eat.

NEW HORSES ADDED

As team No. 2 was later disposed of they were no longer used in these tests, but three new teams were added. Team No. 7, hoof Nos. 72 and 73, were used by the Dairy Department, as were also team No. 9, hoof Nos. 76 and 77, a five and six year old pair of geldings, which showed a predominance of American Trotting Horse blood. Team No. 8, hoof Nos. 74 and 75, were a pair of five year old grade geldings, which showed no particular predominance of any blood unless it was of the American Trotting Horse. They were used by the Grounds Department in caring for the University campus and drives. Nos. 76 and 77 were used on the University milk wagon for the retail delivery of milk thru the city. They worked seven days per week or twenty-eight days a period where the other horses in the experiment worked only twenty-four days per period at the most, often less. This team made the route every day regularly regardless of weather, usually starting at 7 a. m. and returning by 12:30 noon, sometimes a little earlier and sometimes a little later. The wagon to which they were hitched weighed 1280 pounds empty and 2400 pounds loaded; the usual route was thirteen miles long.

With the discontinuing of team No. 2 and the addition of three new teams it became necessary to re-lot the horses in order to balance the lots and make them as nearly uniform as possible. Teams Nos. 1 and 3 were reversed so that Nos. 52 and 59 were designated Lot 1 and Nos. 51 and 60 Lot 2.

TABLE 5.—TEAM NUMBER, HOOF NUMBER, LOT NUMBER, METHOD OF FEEDING GRAIN, AND INITIAL AND FINAL WEIGHT AND GAIN OF HORSES

Team	Hoof No.	Lot No.	Method of feeding grain Mar. 27 to June 19, '09	Weight		Gain or loss lb.	Method of feeding grain June 19 to Aug. 14, '09	Weight Aug. 14, 1909	Gain or loss lb.
				Mar. 27	June 19				
1	52	1	Not mixed with hay.....	1353	1306	−47	Mixed with chaffed clover	1343	37
	51	2	Mixed with hay..........	1356	1297	−59	Not mixed with hay.....	1305	8
3	59	1	Not mixed with hay.....	1241	1165	−76	Mixed with chaffed clover	1162	− 3
	60	2	Mixed with chaffed clover	1391	1319	−72	Not mixed with hay.....	1292	−27
4	64	1	Not mixed with hay.....	1395	1334	−61	Mixed with chaffed clover	1312	−22
	65	2	Mixed with chaffed clover	1405	1381	−24	Not mixed with hay.....	1367	−14
5	66	1	Not mixed with hay.....	1361	1333	−28	Mixed with chaffed clover	1329	− 3
	67	2	Mixed with chaffed clover	1295	1273	−22	Not mixed with hay.....	1261	−12
6	69	1	Not mixed with hay.....	1537	1482	−55	Mixed with chaffed clover	1489	7
	68	2	Mixed with chaffed clover	1429	1399	−30	Not mixed with hay.....	1392	− 7
7	72	1	Not mixed with hay.....	1309	1233	−76	Mixed with chaffed clover	1249	16
	73	2	Mixed with chaffed clover	1303	1251	−52	Not mixed with hay.....	1281	30
8	74	1	Not mixed with hay.....	1251	1221	−30	Mixed with chaffed clover	1231	10
	75	2	Mixed with chaffed hay..	1270	1250	−20	Not mixed with hay.....	1252	2
9	76	1	Not mixed with hay.....	1003	1003	00	Mixed with chaffed clover	993	−10
	77	2	Mixed with chaffed clover	1094	1069	−25	Not mixed with hay....	1071	2
Average for		1	Not mixed with hay.....	1306	1259	−47	Mixed with chaffed clover	1264	4
		2	Mixed with chaffed clover	1318	1280	−38	Not mixed with hay.....	1278	− 2

Table 5 gives the lotting of the horses, method of feeding grain, weight and gain of the individual horses. The above table shows that the horses receiving the grain mixed with chaffed hay lost slightly less in weight during the first part of the test and gained more during the last part, making a total difference of 15 pounds per horse in favor of the grain mingled with chaffed hay.

Thruout this trial the horses in each team did approximately the same amount of work in all instances and consumed approximately the same amount of grain. The hay fed to both lots of horses was of the same quality and approximately the same amount, the only difference being the clover which was chaffed and fed with the grain to Lot 2 during the first part of the test and Lot 1 during the last part. The timothy fed in the evening was given whole to both lots of horses. It appeared that No. 77 of team 9 weighed a little too heavy at the beginning of the experiment as his weight record shows a decrease in weight of 32 pounds the first period and after that he maintained his weight quite regularly or increased slightly. No other horse in the experiment showed such a marked falling off at the beginning and maintained his weight so well afterwards, which indicates that this horse's weight was a little above normal at the beginning of the test. Team Nos. 1 and 3 received some bran during the first period. This was given in a bran mash, which was fed on Saturday evenings at which time the regular grain feed was omitted. At the beginning of the third period bran and oil meal were introduced into the ration of all horses and fed with the regular grain feed.

The average weights by periods of this test are given in Tables 6 and 7. A study of these averages will show that Lot 2, the horses receiving the grain mixed with chaffed clover, received .4 pound more grain per day and .3 pound more hay than those not having the grain mixed with hay during the first three periods. Lot 2 lost only 38 pounds during this time while Lot 1 lost 47 pounds.

At the beginning of the fourth period the method of feeding the grain was reversed so that the horse in Lot 1, which previously received the grain unmixed with hay now received it mingled with chaffed clover, while those in Lot 2 received the grain unmixed with hay. A summary of the averages per horse by periods is given in the latter part of Tables 6 and 7. It will be noticed here that the total grain of Lot 1 was .3 pound more per day than that fed Lot 2, while the hay was exactly the same. The results show that the horses receiving the grain mixed with chaffed clover made a total of four pounds of gain per horse while those not having the grain mixed with hay lost two pounds and all the horses did practically an equal amount of labor. These data show that during the entire five periods the horses receiving grain mixed with chaffed clover lost only 35 pounds while those receiving the grain fed in the usual manner lost 49 pounds, making a difference of 14 pounds in favor of the horses receiving the grain mixed with chaffed clover. While the results show a saving due to mixing the grain with chaffed hay, ordinarily it is not sufficient to justify the expense.

Numerous observations were made of the condition of the feces of the various horses in order to note from a physical examination if more grain was excreted in one lot of horses than the other. It is rather difficult to detect ground grain in the feces and as there

TABLE 6.—SUMMARY LOT 1, AVERAGE PER HORSE BY PERIODS AND GENERAL AVERAGE

4 week periods ending	Period	Average daily grain, lb.					Average daily hay, lb.			Average weight end of period, lb.	Gain or loss lb.	Total labor, hours		Average daily labor, work days, hours
		Cracked corn	Ground oats	Oil meal	Bran	Total	Timothy	Whole clover	Total			Hard	Medium	
GRAIN NOT MIXED WITH HAY. PERIODS 1 TO 3 INCLUSIVE														
April 24.	1	7.16	7.16		.14	14.46	7.5	7.66	15.16	1292	−15	125.94	45.9	7.05
May 22..	2	7.58	7.58			15.16	7.5	7.89	15.39	1263	−29	155.6	44.4	8.27
June 19.	3	6.27	6.27	.92	2.52	15.98	7.23	7.73	14.96	1260	−3	145.6	35.6	7.44
Total...		21.01	21.01	.92	2.66	45.60	22.23	23.28	45.51	3815	−47	427.14	125.9	22.76
Average		7.00	7.00	.31	.89	15.20	7.41	7.76	15.17	1272	−16	142.38	41.97	7.59
GRAIN MIXED WITH CHAFFED CLOVER. PERIODS 4 TO 5 INCLUSIVE														
								Chaffed Clover						
July 17.	4	6.11	6.11	.98	2.89	16.09	7.19	7.48*	15.07	1253	−7	140.1	37.9	7.29
Aug. 14.	5	6.30	6.30	.99	2.95	16.54	7.25	7.89	15.14	1263	10	154.91	60.7	8.85
Total...		12.41	12.41	1.97	5.84	32.63	14.44	15.37	30.21	2516	3	295.01	98.6	16.14
Average		6.21	6.21	.99	2.92	16.32	7.22	7.69	15.12	1258	2	147.51	49.3	8.07

* .4 of a pound of whole clover was fed in addition to the chaffed.

TABLE 7.—SUMMARY LOT 2, AVERAGE PER HORSE BY PERIODS AND GENERAL AVERAGE

GRAIN MIXED WITH CHAFFED CLOVER. PERIODS 1 to 3 INCLUSIVE

4 week periods ending	Period	Average daily grain, lb.					Average daily hay, lb.			Average weight end of period, lb.	Gain or loss lb.	Total labor, hours		Average daily labor, work days, hours
		Cracked corn	Ground oats	Oil meal	Bran	Total	Tim-othy	Chaffed Clover	Total			Hard	Medium	
April 24....	1	7.44	7.44	......	.17	15.05	6.95	8.51	15.46	1309	− 9	123.47	46.5	6.98
May 22.....	2	7.89	7.89	......	......	15.78	7.	8.64	15.64	1286	−23	160.2	43.4	8.39
June 19....	3	6.29	6.29	.92	2.48	15.98	7.21	8.10	15.31	1280	− 6	147.3	35.6	7.52
Total......	...	21.62	21.62	.92	2.65	46.81	21.16	25.25	46.41	3875	−38	430.97	125.5	22.89
Average...	...	7.21	7.21	.31	.88	15.60	7.05	8.42	15.47	1292	−13	143.66	41.83	7.63

GRAIN NOT MIXED WITH HAY. PERIODS 4-5 INCLUSIVE

								Whole Clover						
July 17.....	4	6.03	6.03	.97	2.88	15.91	7.24	7.46*	15.11	1273	− 7	139.	37.9	7.26
August 14..	5	6.18	6.16	.98	2.91	16.23	7.25	7.87	15.12	1278	5	154.91	53.3	8.55
Total......	...	12.21	12.19	1.95	5.79	32.14	14.49	15.33	30.23	2551	− 2	293.91	91.2	15.81
Average...	...	6.11	6.10	.98	2.90	16.07	7.25	7.67	15.12	1276	− 1	146.96	45.6	7.91

*.4 of a pound of chaffed clover was fed in addition to the whole.

was no chemical analysis made there was no means of determining the quantity passed in this manner. However, it appeared from the closest observation that could be made that manure from the horses receiving ground grain mingled with chaffed hay had less grain in evidence than those receiving the grain unmixed with hay. Where the hay and grain were mixed the feces seemed to be in a better condition and the general condition of the horses appeared to be slightly better, as indicated by their coat of hair.

Where horses are fed a heavy grain ration near the limit in quantity, it is believed it is beneficial in preserving the health of the horse to mingle the grain with chaffed hay, altho the results of this test do not show any marked saving. No. 60, which was subject to colic, had fewer attacks when his grain was mixed with chaffed hay than when fed separate. Where the grain is fed with chaffed hay horses are obliged to consume their grain much more slowly and consequently masticate it more thoroly. Corn being a very concentrated and carbonaceous feed sometimes produces deleterious results when fed alone in large quantities. It is believed, however, that its principal danger as a feed for horses is its small amount of crude fiber and low protein content. If a sufficient amount of crube fiber in some form or other were introduced into the ration it would produce a feed which would compare more nearly with oats. For this purpose choice clover or alfalfa hay is preferred to timothy or straw for the reason that the clover and alfalfa furnish more protein than timothy and, too, the ends of chaffed alfalfa and clover are not nearly so sharp on the horse's mouth as chaffed timothy or straw.

CHAFFED CLOVER COMPARED WITH CHAFFED ALFALFA

At the close of the above test on August 14, 1909, the horses in Lot 1 continued to receive their grain mixed with chaffed clover hay, while those in Lot 2 were given their grain mixed with chaffed alfalfa. This test extended over five periods, from August 14 to January 1, 1910, in which chaffed clover was compared with chaffed alfalfa, as a supplement for the grain. The results of this test giving the average daily grain and hay by periods, weight, gain and labor record are set forth in Tables 8 and 9.

Tables 8 and 9 show that the horses receiving alfalfa, received one-fourth pound less grain and one-third pound less hay per horse per day than those receiving the chaffed clover. Those receiving alfalfa did approximately the same amount of labor with less grain and less hay and made a little more gain than those receiving clover. During this experiment it will be noticed that the alfalfa was gradually increased so that the horses became accustomed to it and there was an opportunity to study its effect upon them.

TABLE 8.—SUMMARY LOT 1.—AVERAGE PER HORSE RECEIVING GRAIN MIXED WITH CHAFFED CLOVER, BY PERIODS, AND GENERAL AVERAGE

4 week periods ending	Period	Average daily grain, lb.					Average daily hay, lb.				Average weight end of period	Gain or loss lb.	Total labor, hours		Average daily labor work days, hours
		Cracked corn	Ground oats	Oil meal	Bran	Total	Timothy	Clover		Total			Hard	Med.	
								Whole	Chaffed						
Sept. 11, '09	1	6.08	6.08	.99	2.97	16.12	7.46		7.46	14.92	1263		119.15	91.4	8.6
October 9..	2	5.75	5 75	.95	2.79	15.24	7.50		7.39	14.89	1271	+ 8	163.5	11.	7.22
November 6	3	6.04	6.04	.99	2.94	16.01	6.54	1.78	7.61	15.93	1299	+28	101.	64.41	6.78
December 4	4	6.08	6.08	1.	2.96	16.12	6.26	2.	7.64	15.92	1302	+ 3	116.97	55.9	7.12
Jan. 1, 1910	5	5.73	5.73	.94	2.79	15.19	6.25	2.	7.56	15.81	1323	+21	104.03	46.22	6.16
Total		29.68	29.68	4.87	14.45	78.68	34.01	5.78	37.66	77.47	6458	+58	604.65	268.93	35.88
Average ...		5.94	5.94	.97	2.89	15.74	6.80	1.16	7.53	15.49	1292	+12	120.93	53.79	7.18

TABLE 9.—SUMMARY LOT 2.—AVERAGE PER HORSE RECEIVING GRAIN MIXED WITH CHAFFED ALFALFA, BY PERIODS, AND TOTAL AVERAGE

								Alfalfa							
								Whole	Chaffed						
Sept. 11, '09	1	5.94	5.94	.98	2.9	15.76	7.95		5.96	13.91	1281	+ 3	115.44	92.56	8.51
October 9..	2	5.7	5.7	.95	2.8	15.15	7.8		6.18	13.98	1298	+17	159.5	10.9	7.05
November 6	3	5.94	5.94	.99	2.93	15.80	6.85	1.78	7.22	15.85	1326	+28	94.97	66.78	6.83
December 4	4	6.02	6.02	1.	2.96	16.00	6.63	2.	7.43	16.06	1333	+ 7	116.84	56.4	7.12
Jan. 1, 1910.	5	5.66	5.66	.93	2.77	15.02	6.49	2.	7.34	15.83	1347	+14	102.66	47.47	6.15
Total		29.26	29.26	4.85	14.36	77.73	35.72	5.78	34.13	75.63	6585	+69	589.41	274.11	35 66
Average ...		5.85	5.85	.97	2.87	15.54	7.10	1.16	6.83	15.13	1317	+14	177.88	54.82	7.13

ALFALFA COMPARED WITH TIMOTHY

In order to further study the effect of alfalfa hay in the ration for work horses it was decided to compare it with timothy hay. The plan of the test was the same as previously, excepting that one horse in each team should receive alfalfa hay and the other horse timothy hay. January 1, Lot 1, the horses receiving the chaffed clover, was changed to a ration where the hay fed was all timothy while Lot 2 was continued on part timothy and part alfalfa. During the first period of the test Lot 1 was given their grain mingled with chaffed timothy and Lot 2 with chaffed alfalfa. Because some of the horses seriously objected to consuming the chaffed timothy, due perhaps to the exceedingly sharp ends of the timothy straw, the chaffed timothy was discontinued at the end of Period 1 and also the chaffed alfalfa. From this time on the grain was not mixed with chaffed hay for any of the horses. From 10½ to 11 pounds of alfalfa and 5 pounds of timothy per horse was fed daily to Lot 2 until the end of the period when they were put on all alfalfa. The summary of the results of this test are set forth in Tables 10 and 11.

It will be noticed that the horses of Lot 2, receiving timothy and alfalfa, received nearly one pound less grain per horse per day and .2 pound more hay than those of Lot 1, which received all timothy hay during the first three periods of the experiment from January 1 to March 26. During this time the horses receiving the alfalfa hay lost seven pounds per horse, while Lot 1 lost nine pounds and all did approximately the same amount of labor. These data would indicate that where alfalfa hay is fed as part of the roughage ration, it will in a measure replace some of the grain.

At the beginning of the next period, March 28, 1910, a new team, No. 10 was introduced into the experiment and at the close of the first period, April 23, team No. 3 was no longer used, as they were later disposed of. From March 26 to May 21 Lot 1 continued to receive timothy as the roughage and Lot 2 were given all alfalfa with the exception of a few feeds of timothy, which were fed to some of the horses through error.

The latter part of Table 11 shows that the horses receiving timothy hay received four pounds more grain per horse per day than those receiving alfalfa. Both lots of horses lost approximately the same amount during the two periods Lot 1, 13 pounds and Lot 2, 12 pounds. The horses receiving the alfalfa hay did an average of nearly one-half hour less work per day than those receiving timothy; this difference being due largely to No. 75, which was unable to work part of the time on account of lameness caused from poor shoeing. It will be noticed that this horse did not maintain his weight any better than the other horses, even tho he did not work all the time.

TABLE 10.—SUMMARY LOT 1, AVERAGE PER HORSE RECEIVING TIMOTHY, BY PERIODS FROM 1 TO 3 INCLUSIVE, AND GENERAL AVERAGE

4 week periods ending	Period	Average daily grain, lb.					Average daily hay, lb.			Average weight at end of period, lb.	Gain or loss, lb.	Total labor, hours		Average daily labor work days, hours
		Cracked corn	Ground oats	Oil meal	Bran	Total	Timothy Whole	Timothy Chaffed	Total			Hard	Medium	
Jan. 29.....	1	5.15	5.15	.79	2.20	13.29	7.69	7.49†	15.25	1328	5	64.3	56.91	5.48
Feb. 26....	2	5.01	5.01	.75	2.03	12.80	15.20	......	15.2	1328	......	91.7	70.22	6.65
Mar. 26....	3	5.55	5.55	.84	2.31	14.25	15.27	......	15.27	1295	—33	174.2	18.1	7.91
Total......		15.71	15.71	2.38	6.54	40.34	38.16	7.49	45.72	3951	—28	330.2	145.23	20.04
Average...		5.23	5.23	.79	2.18	13.45	12.72	2.46	15.24	1317	— 9	110.1	48.41	6.68
April 23....	4*	6.86	6.86	1.05	2.74	17.51	15.28	......	15.28	1306	—18	182.2	16.4	8.19
May 21....	5	7.26	7.26	.98	2.94	18.44	15.54	......	15.54	1302	— 8	181.4	19.9	8.28
Totals.....		14.12	14.12	2 03	5.68	35.95	30.82	......	30.82	2606	—26	363.6	36.3	16.47
Average...		7.06	7.06	1.02	2.84	17.98	15.41	......	15.41	1303	—13	181.8	18.2	8.24

† .57 of a pound of whole clover was fed in addition to the timothy.
* 9 horses during period 4.

TABLE 11.—SUMMARY LOT 2, AVERAGE PER HORSE RECEIVING TIMOTHY AND ALFALFA, BY PERIODS FROM 1 TO 3 INCLUSIVE, AND GENERAL AVERAGE

4 week periods ending	Period	Average daily grain, lb.					Average daily hay, lb.				Average weight at end of period, lb.	Gain or loss, lb.	Total labor, hours		Average daily labor, work days, hours
		Cracked corn	Ground oats	Oil meal	Bran	Total	Timothy	Alfalfa Whole	Alfalfa Chaffed	Total			Hard	Medium	
Jan. 29..	1	5.18	5.18	.08	2.12	12.56	4.59	3.43	7.19	15.21	1359	12	73.4	60.16	5.48
Feb. 26..	2	5.07	5.07	......	1.67	11.81	4.9	10.66	......	15.5	1368	9	91.9	67.28	6.57
Mar. 26..	3	5.70	5.47	......	2.02	13.19	4.94	10.52	......	15.46	1327	—41	183.	17.7	8.25
Total...		15.95	15.72	.08	5.81	37.56	14.43	24.61	7.19	46.23	4054	—20	348.3	145.14	20.50
Average		5.32	5.24	.03	1.94	12.52	4.81	8.20	2.40	15.41	1351	— 7	116.1	48.38	6.83
April 23	4*	6.82	6.82	......	.11	13.75	.34	14.92	......	15.26	1331	—13	181.	15.7	8.00
May 21..	5	7.14	7.04	......	......	14.18	.12	15.31	......	15.43	1316	—10	170.	17 9	7.72
Total...		13.96	13.86	......	.11	27.93	.46	30.23	......	30.69	2647	—23	351.	33.6	15.72
Average		6.98	6.93	......	.05	13.96	.23	15.12	......	15.35	1324	—12	176.	16.8	7.86

* 9 horses used during period 4.

During the time Lot 2 received all alfalfa, the oil meal and bran was discontinued from their ration with the exception of a very small amount which was fed at the beginning of the test.

The results of this test indicate that when a mixed grain ration of corn and oats is fed in conjunction with alfalfa, 20 to 22 per cent less grain is needed to maintain the weight of work horses, than where the grain is fed in conjunction with timothy.

CORN AND ALFALFA COMPARED WITH CORN, OATS, BRAN, OIL MEAL, TIMOTHY AND ALFALFA

At the close of the above test it was decided to continue feeding some of the horses on alfalfa and omit the oats from the grain ration, feeding all corn. One horse in each of three teams was fed in this manner, while the other horse received a mixed grain ration of corn, oats, oil meal and bran and a small amount of alfalfa replaced a part of the timothy. The test extended over two periods from May 21 to July 16, the results of which are set forth in Tables 12 and 13.

It will be noticed that the horses in the various lots did an equal amount of labor. The horses getting the mixed ration with timothy and alfalfa hay received an average daily ration of 18.16 pounds grain while those of Lot 2 receiving corn and alfalfa got only 14.1 pounds grain per day. Both lots of horses received the same amount of hay. This helps to emphasize the conclusion of the previous test, that where alfalfa is fed it will in a measure replace a part of the grain; in this case about 22 percent. At the prices of feed given on page 435, the ration of corn and alfalfa cost 6 cents less per horse per day than the mixed ration, which would ordinarily mean a saving of $15.00 to $20.00 per horse annually. Those getting the corn and alfalfa lost an average of eight pounds per horse while the others lost only two pounds per horse. At no time during the test were there noticed any deleterious results from the feeding of alfalfa. The horses ate it with more relish than timothy and it did not prove to be as loosening to the bowels as clover. The alfalfa hay fed was bought for choice quality but some of it contained a few sand-burrs. Part of the hay came from Nebraska and part was purchased from a Kansas City firm. The timothy hay fed from March 26 on was not all of the best quality, some of it being slightly mixed with red top and blue grass.

GROUND GRAIN COMPARED WITH WHOLE GRAIN

At the close of the test in which alfalfa was compared with timothy hay where a mixed grain ration of corn and oats was fed, it was decided to conduct a short test of six weeks in which

TABLE 12.—SUMMARY LOT 1, AVERAGE PER HORSE RECEIVING MIXED GRAIN, TIMOTHY AND ALFALFA BY PERIODS AND GENERAL AVERAGE

4 week periods ending	Period	Average daily grain, lb.					Average daily hay, lb.			Average weight end of period, lb.	Gain or loss lb.	Total labor, hours		Average daily labor, work days, hours
		Cracked corn	Ground oats	Oil meal	Bran	Total	Tim-othy	Al-falfa	Total			Hard	Medium	
June 18....	1	7.08	7.08	1.	3.	18.16	11.3	3.68	14.98	1217	5	177.3	16.2	7.8
July 16.....	2	7.08	7.08	1.	3.	18.16	11.3	3.67	14.97	1208	– 9	175.	15.3	7.7
Total	...	14.16	14.16	2.	6.	36.32	22.6	7.35	29.95	2425	– 4	352.3	31.5	15.5
Average ...	...	7.08	7.08	1.	3.	18.16	11.3	3.68	14.98	1213	– 2	176.2	15.8	7.8

TABLE 13.—SUMMARY LOT 2, AVERAGE PER HORSE RECEIVING CORN AND ALFALFA BY PERIODS, AND GENERAL AVERAGE.

	Period	Average daily grain, lb.	Average daily hay, lb.	Average weight end of period, lb.	Gain or loss lb.	Total labor, hours		Average daily labor, work days, hours
		Cracked corn	Alfalfa			Hard	Medium	
June 18....	1	14.	14.98	1275	–19	177.3	16.	7.9
July 16.....	2	14.2	15.	1278	3	173.5	15.3	7.6
Total	...	28.2	29.98	2553	–16	350.8	31.3	15.5
Average ...	...	14.1	14.99	1277	– 8	175.4	15.7	7.8

TABLE 14.—SUMMARY LOT 1, AVERAGE PER HORSE RECEIVING WHOLE GRAIN BY PERIODS, AND GENERAL AVERAGE

Dates	Period	Average daily grain, lb.					Average daily hay, lb.			Average weight end of period, lb.	Gain or loss, lb.	Total labor, hours		Average daily labor work days, hours.
		Whole corn	Whole oats	Oil meal	Bran	Total	Tim-othy	Al-falfa	Total			Hard	Medium	
June 4— June 18..	1	8.22	7.85	......	2.94	19.01	12.45	3.57	16.02	1362	20	99.5	6.9	8.87
June 18— July 16...	2	7.44	7.54	......	2.85	17.83	11.69	3.45*	15.55	1360	— 2	187.4	20.	8.64
Total......		15.66	15.39	......	5.79	36.84	24.14	7.07	31.57	2722	18	286.9	26.9	17.51
Average...		7.83	7.69	......	2.89	18.42	12.07	3.54	15.79	1361	9	143.5	13.5	8.76

* .41 clover.

TABLE 15.—SUMMARY LOT 2, AVERAGE PER HORSE RECEIVING GROUND GRAIN BY PERIODS, AND GENERAL AVERAGE

	Period	Average daily grain, lb.					Average daily hay, lb.			Average weight end of period, lb.	Gain or loss, lb.	Total labor, hours		Average daily labor work days, hours.
		Cracked corn	Ground oats	Oil* meal	Bran	Total	Tim-othy	Al-falfa	Total			Hard	Medium	
June 4— June 18..	1	7.11	7.11	.2	2.97	17.39	12.11	3.6	15.71	1367	21	99.7	6.9	8.89
June 18— July 16..	2	6.9	6.9	.19	2.86	16.85	12.36	3.6	15.96	1369	2	188.4	20.	8.68
Total......		14.01	14.01	.39	5.83	34.24	24.47	7.2	31.67	2736	23	288.1	26.9	17.57
Average...		7.01	7.01	.20	2.92	17.12	12.24	3.6	15.84	1368	12	144.1	13.5	8.79

* Horse No. 74 in Lot 2 was fed a small amount of oil meal by mistake.

ground grain would be compared with whole grain. As a preliminary for this test two weeks were allowed to elapse, in which Teams Nos. 1, 5, 6, 8, and 10 were fed on the same kind of grain and hay. The test began on June 4 and extended to July 16. The horses in Lot 1 received whole grain, consisting of ear corn, whole oats and bran, while those in Lot 2 received cracked corn, ground oats, and bran the same as Lot 1. Both lots of horses received one feed of alfalfa hay of from three to four pounds and two feeds of timothy hay per day. The ear corn fed was figured on a basis of shelled corn. The summary of the results of this test are given in Tables 14 and 15.

It will be noticed from Tables 14 and 15 that the horses getting whole grain received 18.42 pounds per horse per day while those getting the ground grain received 17.12 pounds per horse per day. The hay fed both lots was approximately the same. The horses receiving the whole grain made a total gain of 18 pounds, and those receiving the ground grain made a total gain of 23 pounds. Considering that one ration was approximately as good as the other it will be seen that there was about 9 percent less grain fed where it was ground than where fed whole. Whether or not it will pay to grind grain for horses will depend much upon the convenience and expense of grinding and also upon the amount of work performed by the horse. When the teeth of the horses are good they will do very well on whole grain but when horses are worked near their limit and it is desired to conserve all the possible energy for labor there may be economy in grinding. Ground grain is slightly more digestible than whole grain and it is usually considered by best authorities that a ten percent saving in the grain can be effected by grinding, which is in harmony with the results of this test tho it was too short to be conclusive. It is believed that when the labor is light the saving will not be so great as when the horses are at hard labor.

TABLE 16.—AVERAGE DAILY COST OF RATIONS

Date	Exp.	Lot 1			Lot 2		
		Grain	Hay	Total	Grain	Hay	Total
Apr. 2 to Oct. 15, '08	1	$ .182	$ .095	$ .277	$ .175	$ .079	$ .254
Oct. 15 to Mar. 4, '09	2	.154	.077	.231	.141	.080	.221
Mar. 27 to Aug. 14, '09 ..	3	.173	.083	.256	.173	.083	.256
Aug. 14 to Jan. 1, '10....	4	.174	.084	.258	.172	.113	.285
Jan. 1 to May 21, '10.....	5	.174	.092	.266	.146	.111	.257
May 21 to July 16, '10....	6	.201	.096	.297	.126	.112	.238
June 4 to July 16, '10....	7	.202	.099	.301	.184	.100	.284

COST OF RATIONS FED

It will be noticed from Table 16, which gives the daily cost of the various rations fed, that in experiment 1 where clover hay was fed Lot 2, there was a saving of about two cents per horse per day over that fed Lot 1, or $8.40 per horse per year. This difference is due principally to the fact that clover hay is cheaper than timothy. It will also be seen that the horses in Lot 1 ate slightly more feed than those in Lot 2, which in a measure accounts for the difference in the cost.

During experiment 2 Lot 1 receiving clover hay was fed at an expense of one cent more per horse per day than Lot 2 due to consuming more grain and hay.

There was no difference in the cost of the rations in the third experiment as both lots of horses received the same kind of feed and practically the same quantity. It will be remembered that the clover hay fed one lot was chaffed and mingled with grain, but no account has been taken of the labor involved in its preparation.

During the 4th experiment it will be noticed that where alfalfa was fed Lot 2 the ration cost about three cents more per horse per day than Lot 1, which received clover.

Where alfalfa and timothy were compared in experiment 5, the ration of Lot 2 receiving alfalfa was about one cent cheaper than that of Lot 1. The grain part of the ration of lot 2 was about three cents cheaper than that of Lot 1 because of the smaller amount consumed, but alfalfa being more expensive than timothy the economy of the ration fed Lot 2 is only slight.

The greatest economy in making up a ration is brought out in experiment 6. That fed Lot 2, corn and alfalfa, was six cents per day cheaper than that fed Lot 1, which consisted of mixed grain ration of corn, oats, bran and oil meal, timothy and alfalfa hay. While the ration fed Lot 2 was entirely satisfactory the test was too short to determine whether or not such a ration would prove satisfactory for an indefinite length of time. A saving of six cents per day would mean a saving of $21.90 per horse per year.

The ration fed Lot 2 in experiment 7 was two cents per horse per day cheaper than that fed Lot 1. This difference may be credited to the effect of grinding, that fed Lot 2 being ground grain while that fed Lot 1 was whole grain.

CONCLUSIONS

1. Where a mixed grain ration of corn, oats, oil meal and bran is fed, clover hay is equally as efficient if not a little superior to timothy for horses at hard work.

2. There was no observable difference in the effect of clover and timothy upon the spirit of the horses or their ability to en-

dure hot weather. Those receiving clover had a glossier coat of hair and their bowels were looser, but not too loose to endure hard work.

3. When clover is used as a horse feed, the quality should be good and the quantity fed limited.

4. A slight saving in grain may be made by mingling it with chaffed hay, but the saving in this test did not appear to be enough to justify the expense.

5. There may be a benefit not shown in these tests, in preserving the horse's health, by mingling the grain with chaffed hay. The results of this test are not conclusive on this point.

6. Where the grain was ground and mingled with chaffed clover and with chaffed alfalfa, the latter proved to be a little more efficient in preventing loss in weight of horses at hard work.

7. The mingling of grain with chaffed timothy hay did not prove satisfactory.

8. Where alfalfa hay is fed as the roughage part of a ration for farm horses at hard work, less grain is necessary to prevent them from losing weight than where timothy hay is fed. In this test there was a saving of about 22 percent of grain.

9. Tho too short to be conclusive these tests indicate that mature horses at hard work can be maintained quite satisfactorily for a short time, at least, on corn fed in conjunction with alfalfa hay, and at a saving in cost.

10. A saving of about ten percent may be made by grinding the grain for farm work horses when at hard labor.

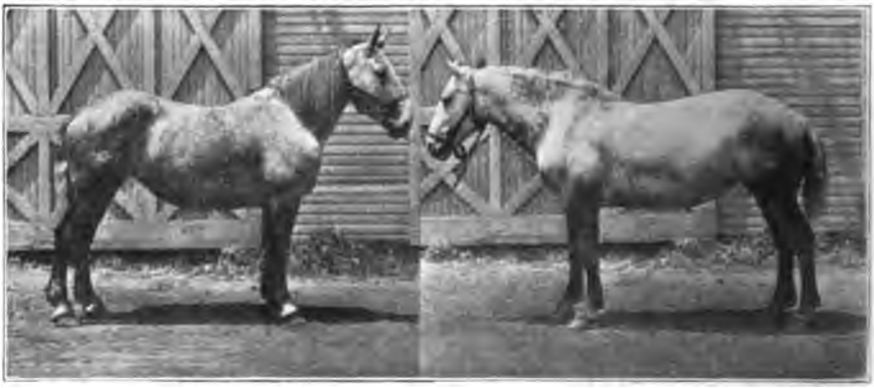
11. It requires twice as long for horses to consume ground grain fed dry, as when the same quantity is fed thoroly dampened.

12. Farm work horses at hard labor should receive from one and one-fifth to one and one-third pounds of grain, and from one to one and one-fourth pounds of hay, per 100 pounds of live weight per day, in order that their weight may be maintained.

13. Satisfactory results have been secured by feeding the grain in three equal feeds, and giving one-half the hay at night, the other half being divided between the morning and noon feeds.

14. The grain fed should be reduced one-half on idle days until four days have elapsed, or until they are again put to work, when it may be again increased if desirable. By following this method attacks of azoturia were prevented.

15. The results of the experiment indicate that the general impression is correct that horses may very properly be given a more bulky ration when idle or doing light work than when at heavy work. It is believed that the practice of permitting work horses to gorge themselves with hay is all too common.



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TEAM No. 1

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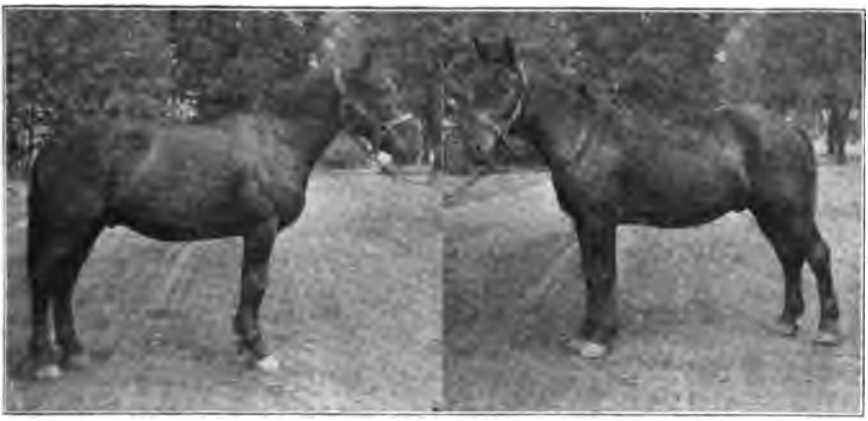
TEAM No. 3



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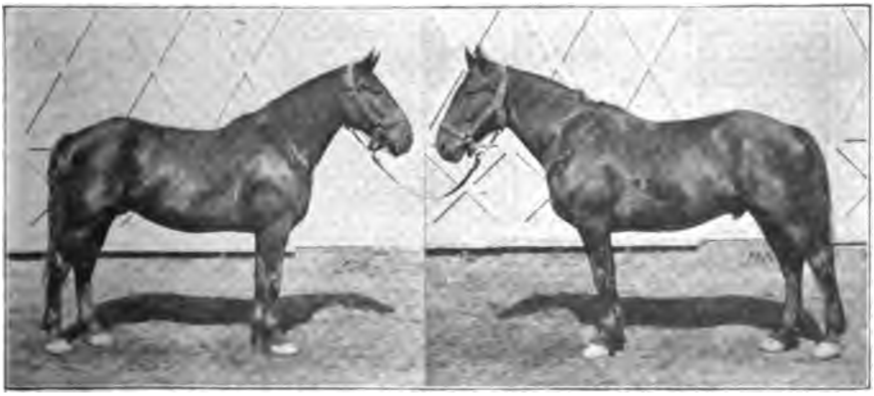

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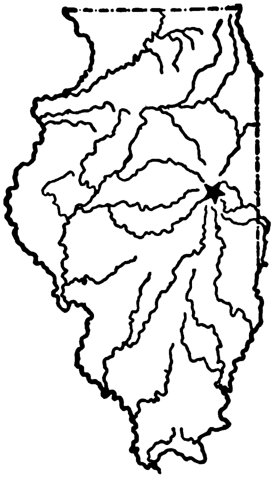
By STEPHEN A. FORBES
State Entomologist



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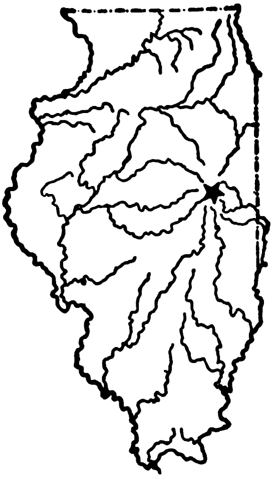

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CONTENTS OF BULLETIN NO. 151

PAGE.
The Catalpa Sphinx (*Ceratomia catalpæ* Bdv.) 464
The Fall Web-worm (*Hyphantria textor* Harr.) 466
The Yellow Poplar-Caterpillar (*Apatela populi* Riley) 468
The Walnut Caterpillar (*Datana integerrima* G. & R.) 470
The White-marked Tussock-moth (*Hemerocampa leucostigma* S. & A.) 472
The Brown-tail and Gypsy Moths (*Euproctis chrysorrhœa* L., and *Porthetria dispar* L.) 476
The Forest Tent Caterpillar (*Malacosoma disstria* Hbn.) 483
The Common Canker-worm (*Paleacrita vernata* Peck) 485
The Lilac Borer (*Podosesia syringæ* Harr.) 489
Two Poplar Borers (*Memythrus tricinctus* Harr. and *M. dollii* Neum.) 493
A Viburnum Borer (*Sesia pictipes* G. & R.) 496
The Maple Borer (*Sesia acerni* Clem.) 497
The Ninebark Borer (*Sesia scitula* Harr.) 499
The Bag-worm (*Thyridopteryx ephemeræformis* Harr.) 500
The Poplar and Willow Borer (*Cryptorhynchus lapathi* Linn.) 502
The Dogwood Twig-girdler (*Oberea tripunctata* Swederus) 506
The Locust Borer (*Cyllene robiniæ* Forst.) 510
The Oak Twig-pruner (*Elaphidion villosum* Fabr.) 512
The Bronze Birch-borer (*Agrilus anxius* Gory) 515
The Scurfy Scale (*Chionaspis furfura* Fitch) 517
The Oyster-shell Scale (*Lepidosaphes ulmi* Linn.) 519
The San Jose Scale (*Aspidiotus perniciosus* Comst.) 520
Putnam's Scale (*Aspidiotus ancylus* Putnam) 523
The Walnut or Willow Scale (*Aspidiotus juglans-regiæ* Comst.) 523
The Cottony Maple Scale (*Pulvinaria vitis* Linn.) 524

SOME IMPORTANT INSECTS OF ILLINOIS SHADE TREES AND SHRUBS

BY STEPHEN A. FORBES, STATE ENTOMOLOGIST

The protection of the shade trees and ornamental shrubs of Illinois against insects has been for several years a problem of rapidly increasing importance. Many of our most desirable trees and shrubs are liable to slow destruction by obscure insect pests understood little if at all by those immediately concerned. Trees which have grown for years, becoming more attractive, more valuable, and more highly valued year by year, begin to weaken and decay, the owner does not know why. This is often due to borers or to scale insects, the presence of which has not been detected or suspected, but whose injuries might have been prevented if the facts had been known in time. More sudden losses are frequently caused by overwhelming attacks of leaf-eating insects which, altho conspicuous, are not dealt with because proper measures of procedure are not known. Observations and experiments upon this subject have been for several years a prominent part of the work of the office. Beginning in 1898, repeated careful examinations have been made of the trees and shrubs of the parks and boulevards of Chicago, and this work has been extended from time to time to other cities and towns thruout the state. With the establishment of a field assistant in Chicago in 1907, the subject received more continuous attention at the hands, first, of Mr. H. E. Hodgkiss and, later, of Mr. John J. Davis, the latter of whom especially has made many studies of the life histories of species previously but little known, and has added a mass of details to our knowledge of the subject in all its parts.

The general subject is still under investigation, and will be in due time reported upon in a much fuller and more elaborate article, but the present brief preliminary paper has been prepared in the hope that it may be found of immediate practical use to municipal authorities in control of parks, boulevards, and streets, to town improvement societies, and to owners of lawns and other private premises the appearance of which they are striving to improve by the use of trees and shrubs.

THE CATALPA SPHINX

(*Ceratomia catalpæ* Bdv.)

One of the most destructive of the few insects to which the catalpa tree is subject is a large showy caterpillar known as the catalpa sphinx (Fig. 1). It is a southern insect, and has not been found in this state north of Clay and Richland counties, altho it has

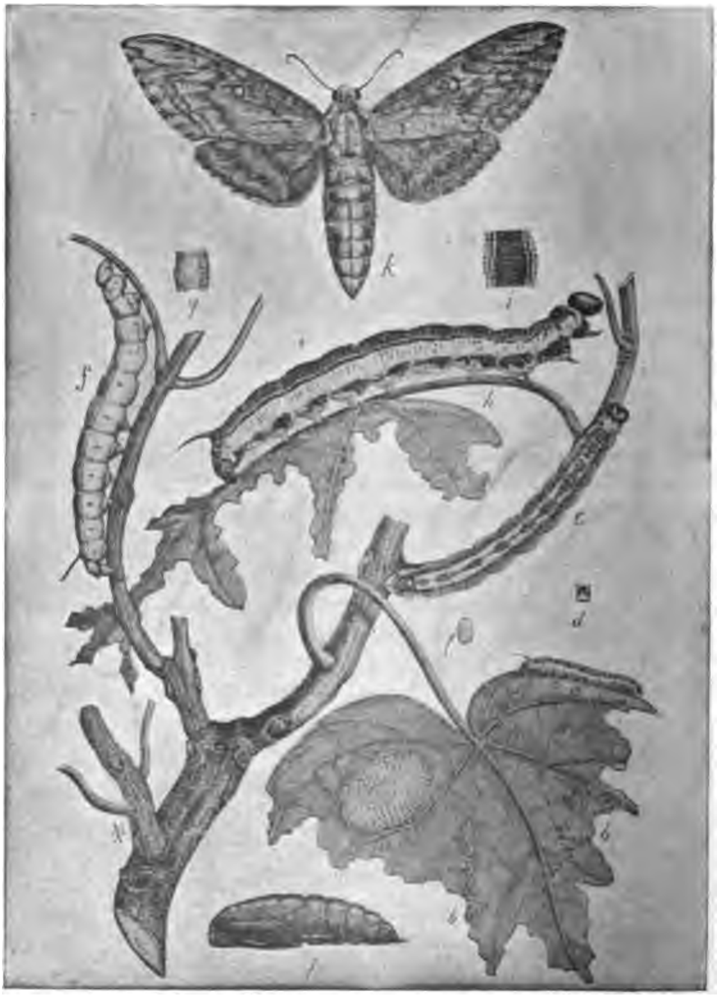

Fig. 1. Catalpa Sphinx (*Ceratomia catalpæ*): *a*, egg mass; *b*, newly hatched larvæ; *c*, *d*, larvæ one-third grown and one joint showing its dorsal pattern; *e*, *f*, *g*, *h*, *i*, mature larvæ, variously marked, and single joints showing dorsal patterns; *j*, pupa; *k*, moth; *l*, egg, enlarged; others all slightly less than natural size. (Ohio Experiment Station.)

extended up the Atlantic coast as far as New Jersey. It is likely to appear suddenly in large numbers upon single trees, stripping them completely.

The full-grown caterpillar (Fig. 1, *e, f, h*) is rather strongly marked, with a broad velvety black stripe on the back and sulphur-yellow sides spotted with black, while the under side of the body is pale green. It is unusually variable in color, however, there being both light and dark forms. It is from two and a fourth to three inches long, and has a hornlike appendage projecting from the hinder end of the back. The young caterpillars (Fig. 1, *c*) are pale yellow and spotted with black. There are probably but two generations in Illinois. The caterpillars leave the trees and go into the ground to pupate (Fig. 2).

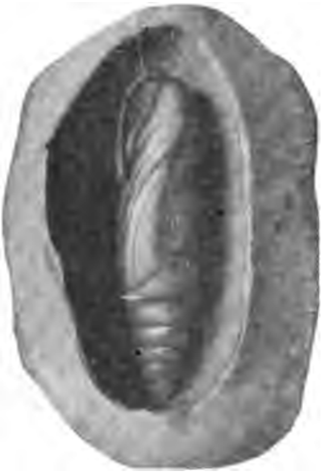

Fig. 2. Catalpa Sphinx, *Ceratomia catalpæ*, pupa in cell in earth.

The parent insect is a large heavy-bodied moth (Fig. 1, *k*) with strong, narrow, brownish-gray wings, with obscure lines and spots of black. The eggs (Fig. 1, *a*) are laid in masses on the leaves, sometimes as many as a thousand in a bunch, and the young, on hatching, feed at first in companies—a fact which makes it easy to destroy them if their presence is detected early, by picking off or spraying the infested leaves. A general spraying of a tree with arsenate of lead or Paris green will destroy the caterpillars at any time. Professor H. Garman, of Kentucky, says that the nearly grown worms can be shaken or jarred down from most catalpa trees and readily destroyed by hand.

THE FALL WEB-WORM

(*Hyphantria textor* Harris)

The fall web-worm is the only common Illinois insect which makes a large conspicuous web in late summer and in fall, inclosing a considerable number of the leaves and twigs of a branch, together

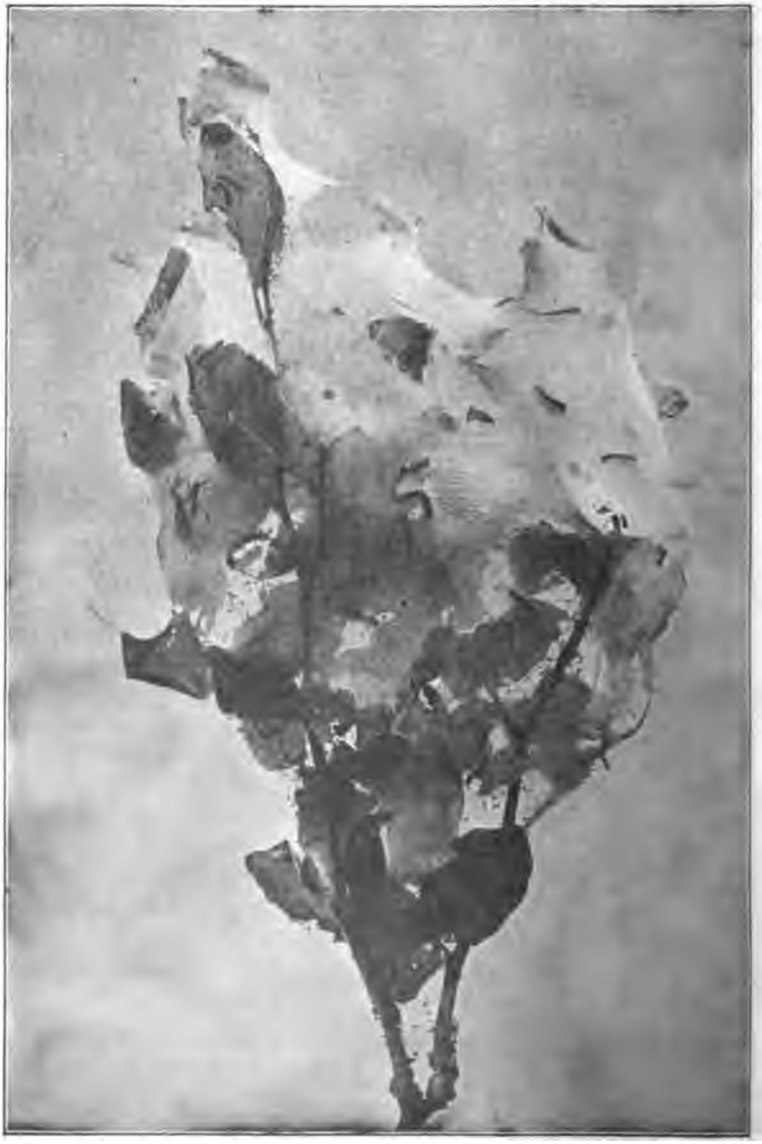

Fig. 3. Fall Web-worms, *Hyphantria textor*, and their web, on apple-tree. (New Hampshire Experiment Station.)

with a colony of caterpillars which feed under its protection (Fig. 3). It is unfortunately often called in Illinois the tent caterpillar, but the latter name is properly applied only to a caterpillar, not often seen in this state, which makes a small compact web in the forks of a branch in spring, which it uses only for protection while not eating.

The web-worm is an almost universal feeder and has been found on about a hundred and twenty species of fruit, shade, and ornamental trees, upon the leaves of which it feeds. It is one of the most annoying pests of the tree grower, its numerous large webs, enclosing brown, skeletonized leaves, making the tree very unsightly, and the injury done, as it spreads from branch to branch, often being considerable. While the caterpillars are growing they do not wander from their common web, but enlarge this to cover fresh leaves as fast as those within it are devoured. When they have nearly completed their growth, however, they scatter far and wide, running briskly about when disturbed, and feeding on almost

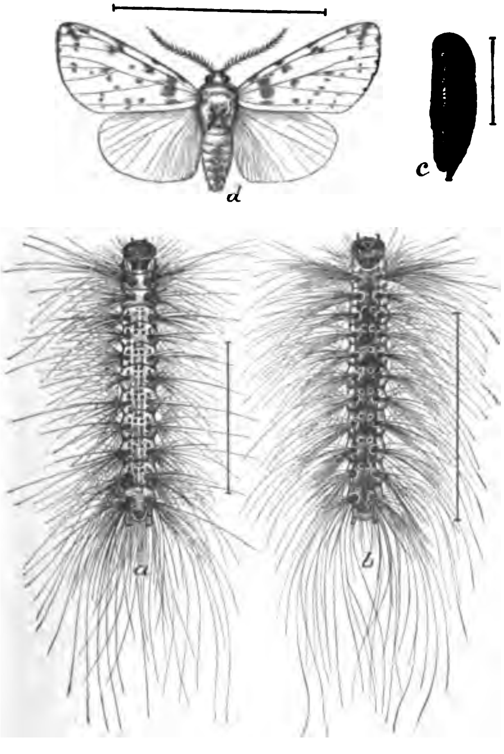

Fig. 4. Fall Web-worm. *Hyphantria textor:* *a, b,* larvæ, light and dark varieties; *c,* pupa; *d,* moth, spotted variety. All slightly enlarged. (New Hampshire Experiment Station.)

every green thing they find. At this time they become, when very abundant, an extremely destructive and annoying pest.

They are about an inch long when full grown, varying from pale yellow or grayish to a dark bluish-black hue. (Fig. 4, *a, b.*) The body is covered with long straight hairs grouped in tufts rising from small black or orange-yellow tubercles, of which there are a number on each segment. When mature, the caterpillars go to the ground, into which they burrow a short distance, or they creep under shelter above ground, where they form slight cocoons of silken web interwoven with the hairs from their bodies. Within these they change to dark brown pupæ (Fig. 4, *c*), and in this condition they pass the winter. The moths emerge in spring and lay their eggs in broad patches of several hundred each, on the under side of the leaves near the end of a branch, late in May and early in June. The adult insect is usually pure white, but is sometimes white spotted with black. There are either one or two broods of this species, according to the latitude, two in southern and central Illinois and probably but one in the northern part of the state.

The simplest and most effective method of controlling these insects is to destroy their webs, and the caterpillars within them, either by cutting off the twigs which bear them and crushing or burning them immediately, or by burning the webs on the tree. A bundle of rags or a few corn-cobs, or even a porous brick, wired to the end of a pole long enough to reach the nest and saturated with kerosene, makes a good torch for the purpose. Care must be taken, however, not to injure the tree, and to destroy the scattering worms which may drop from the nest without being killed. Where the infestation is too general to make this method convenient, or where the webs are so high in the trees that they can not be readily reached, a spray of arsenate of lead will eventually kill the web-worms as they extend their webs over the poisoned foliage. Paris green may be used instead, but the lead arsenate is to be preferred because, being much more adhesive, it lasts longer on the tree. This method is most effective when the caterpillars are young, since they are then extending their webs rapidly and are likely to be more promptly poisoned than when they are virtually full grown.

THE YELLOW POPLAR-CATERPILLAR

(*Apatela populi* Riley)

The prominence of the Carolina poplar as a city tree, especially in situations where it is difficult to find any other which can endure the conditions prevailing, makes it the duty of the Entomologist to discuss the insect enemies of even this rather inferior variety.

Among those which have recently been found most injurious to the poplar is a large and rather handsome, light yellow or pale green, very hairy caterpillar (Fig. 5), most easily known by five long pencil-like tufts of black hairs rising one behind the other on the middle line of the back, the first on the fourth segment of the body and the fifth on the last. This caterpillar was particularly injurious to poplars and considerably so to willows in Chicago in 1909. It has been noticed by us also in Peoria, Danville, and East St. Louis. It feeds on the leaves in midsummer and again in fall, there being two generations in a year. It sometimes completely strips a tree, rendering it unsightly and putting it in poor condition to withstand unfavorable conditions or to resist the attacks of more destructive insects.

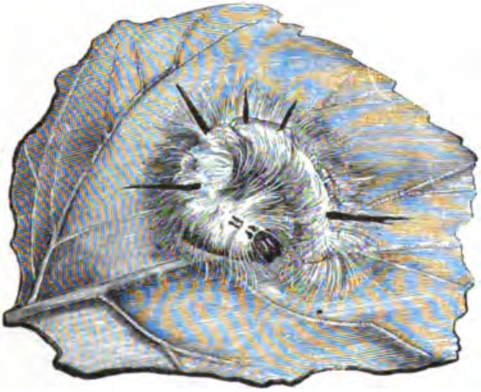

Fig. 5. The Yellow Poplar-Caterpillar, *Apatela populi*, natural size.

The caterpillar when full grown is about an inch and a half long, the skin yellowish-green, and the long, soft, drooping hairs yellow. The pencil-like tufts referred to rise from the fourth, sixth, seventh, and eleventh segments, those on the seventh and eighth being the smallest. The head is shining black and there are black spots on the top of segments one and two. The young are almost white, and the black tufts of hairs are shorter, but still conspicuous. The caterpillar is of a sluggish habit, and when at rest it commonly lies curled up, with the ends of the body together. When full grown it spins a loose, pale yellow cocoon of silk interwoven with its own hairs. This is generally placed in a crevice of the bark, under the edge of a fence board, or in some similar sheltered place. The winter is passed in this chrysalis stage, from which a large, pale gray moth emerges the following May.

The caterpillars are most easily destroyed when young, for they do not at first scatter from the branch upon which they were born.

Later they can readily be collected singly by hand from trees of small size, or they may be poisoned, like most of the leaf feeders, by spraying with arsenicals when they are active on the tree.

THE WALNUT CATERPILLAR

(*Datana integerrima* G. & R.)

The most annoying insect enemy of the walnut is a blackish, somewhat striped, hairy caterpillar (Fig. 6), an inch and a half long when full grown, which eats the leaves during the latter part of the summer, often largely denuding the tree. It makes itself particularly offensive on lawns by dropping quantities of refuse from the tree and by crawling over walks and buildings when it comes down to go into the ground.

This caterpillar is readily distinguished by its loose coat of soft whitish hairs, and particularly by its habit of raising both ends of the body when at rest and throwing itself into this position and jerking sidewise when disturbed. It often attracts attention by collecting in masses upon the larger branches or the trunk of the tree preliminary to molting, piling up in this way two or three layers deep. When full grown it comes down the trunk to the ground, wanders about to a short distance and enters the earth an inch or two, changing there to a reddish-brown or blackish-brown chrysalis (Fig. 6, B). In this stage it winters, emerging the following summer, mainly in June and July, in the form of a buff-brown moth (Fig. 6, A) with darker bands across the fore wings. The females lay their eggs in clusters varying from seventy-five to a hundred, according to some observers, and from five hundred to twelve hundred, according to others, and the young hatching from these feed in dense clusters, completely devouring every leaf as they go. When all the leaves on one twig or branch are destroyed, they migrate to another, sometimes in a distant part of the tree. They lose their gregarious habit as they mature, and by the time they are full grown they scatter here and there over the greater part of the tree. There is but a single generation in a year.

Altho they are most frequently seen on the walnut, they are common on butternuts and hickories, and are a pest to the grower of the pecan. They have likewise been found on beech, oak, willow, honey-locust, apple, and thorn. Trees in the forest are not likely to suffer, but those on streets and lawns are sometimes so completely stripped by September that they stand almost as naked as in midwinter, only the green nuts remaining on the branches.

This account of their habits is sufficient to suggest various available methods of destroying them. On trees small enough to be reached they can be readily killed while young by clipping off the infested twigs on which the caterpillars are grouped in colonies. They are particularly exposed to attack as they assemble in masses for their later molts, when a light spray of kerosene will readily kill them. They are also susceptible to arsenical poisons sprayed

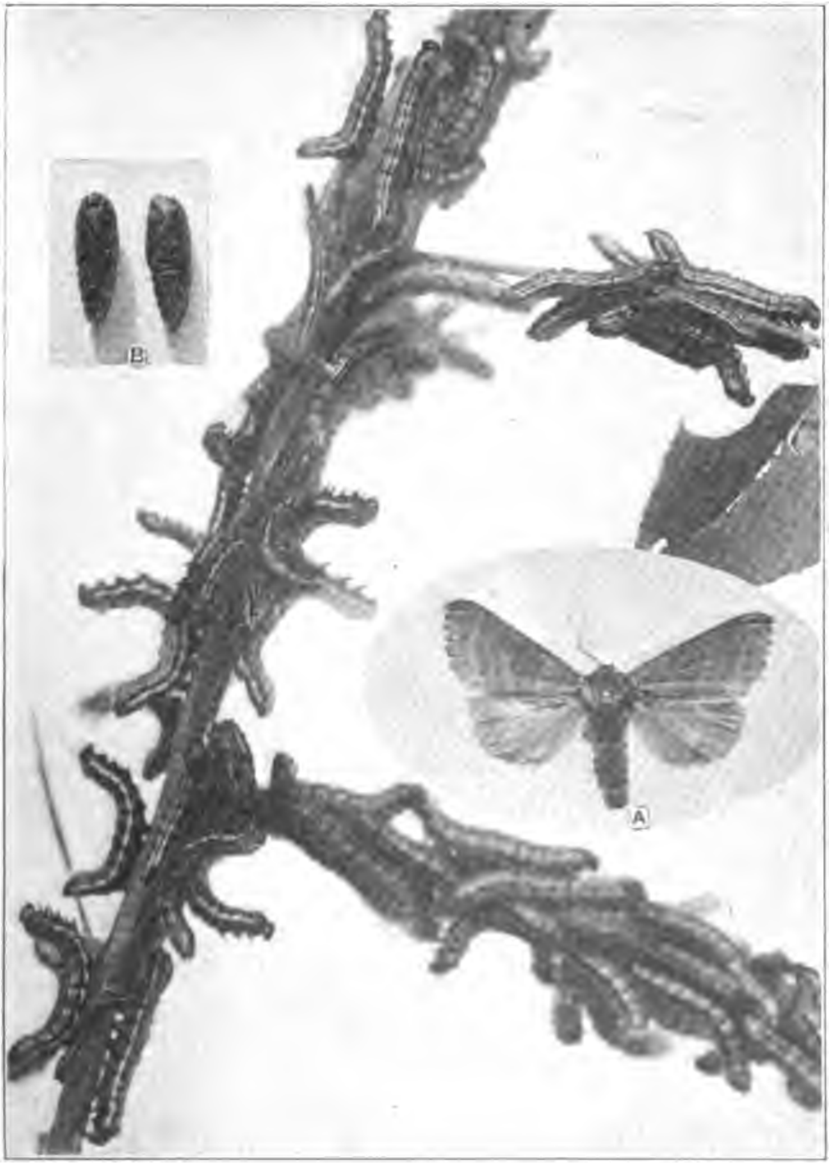

Fig. 6. Walnut Caterpillar, *Datana integerrima*: A, moth; B, pupæ. Natural size. (Kentucky Experiment Station.)

upon the leaves, but these must be used in unusual strength. We have found three pounds of arsenate of lead to fifty gallons of water sufficient to kill the full-grown caterpillars. On one occasion a tree nearly fifty feet high was effectively sprayed by the aid of a twenty-eight-foot ladder and a twelve-foot extension rod with a nozzle on the end, about twenty-five gallons of the spray being necessary for a thoro treatment. If these various measures have been neglected and the caterpillars have left the tree, they may still be disposed of in the pupa stage by digging up and working over the ground under the branches and for a little distance outside, to a depth of three or four inches.

THE WHITE-MARKED TUSSOCK-MOTH

(*Hemerocampa leucostigma* S. & A.)

The most destructive leaf-eater infesting shade trees in the larger cities of Illinois and especially in Chicago is the caterpillar of the white-marked tussock-moth. It often completely defoliates large trees, those most seriously injured being the elm, the soft maple, the linden, the birch, and the horse-chestnut. (Fig. 7.) Almost every kind of tree, excepting conifers, is subject to its attack, and it sometimes becomes decidedly injurious in orchards. In Chicago it has been noted as injurious to apple, box-elder, hard maple, Norway maple, poplar, willow, oak, ash, locust, hickory, catalpa, and sycamore, and to several shrubs, including dogwood, buttonbush, *Viburnum,* and bladdernut (*Ptelea*). In September and October, 1910, it was found in every one of eighteen towns visited by Mr. John J. Davis, present in small numbers in seven of them, common in nine, and in destructive numbers in two.

This is a well-marked insect, very easily recognized, especially the caterpillar and the egg mass—the two conditions against which measures of destruction must be taken. The hairy caterpillar (Fig. 8), bright yellow in general color and striped with black, and about an inch and a half long when full grown, is a really beautiful object. It may be known by its coral-red head, by two plumelike tufts of long black hairs projecting upward and forward from the back near the head, by a single similar tuft at the hind end of the body, and especially by four thick, short, brushlike clusters of cream-colored hairs arranged, one behind the other, in front of the center of the back. In this condition it may be found upon infested trees in June, July, and August.

There are two generations of the caterpillar in a year in northern Illinois, possibly three farther south. The egg masses (Fig. 9) from which the caterpillars hatch may be found in fall, winter, and early spring. They form, when first deposited, frothy, oval, snowy

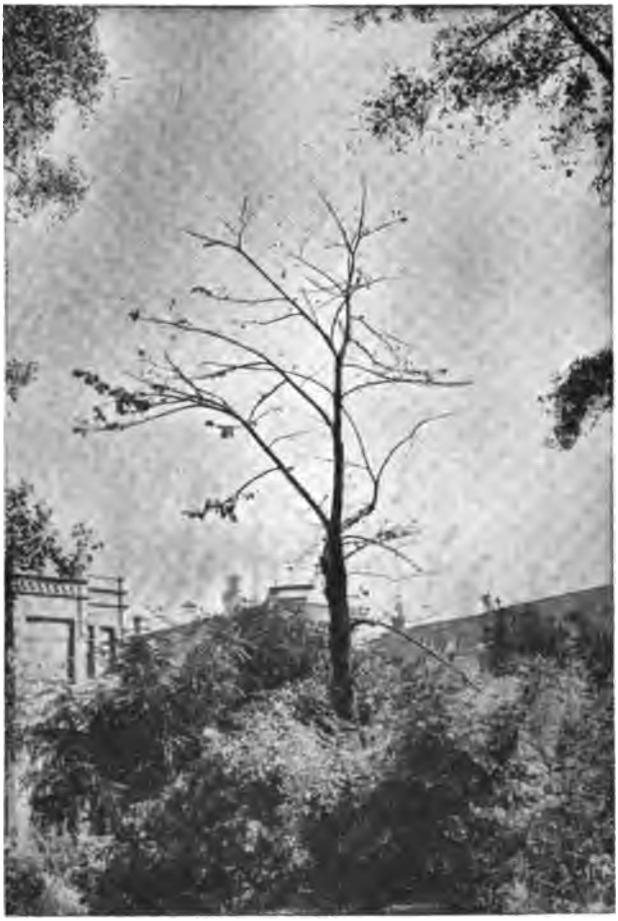

Fig. 7. Linden tree in a park in Chicago, defoliated by larvæ of White-marked Tussock-moth (*Hemerocampa leucostigma*). The few leaves on the tree have all appeared since the defoliation.

white patches about an inch in length, on the tree trunks, in the crotches of the larger branches, or in other more or less sheltered places, such as the edges of weather-boards and the under sides of the eaves of porches. Conspicuous objects at first, their color, under exposure to the sooty air of Illinois towns, is soon deadened to a dirty gray. The caterpillar begins to hatch from the over-wintering egg masses about the middle of June in Chicago (June 18 in 1909) and gets its growth in about a month. Feeding at first on the under side of the leaf, which it skeletonizes by eating off the soft tissue, it later eats inward from the edge of the leaf, devouring everything except the principal veins.

The young caterpillars drop down, hanging by silken threads, when the tree is jarred, and sometimes spin down without being disturbed, when they may be blown to a considerable distance by the wind. When nearly full grown, they are great travelers, going from tree to tree and even moving in large numbers from a defoliated tree to others near by. When full grown, the caterpillar

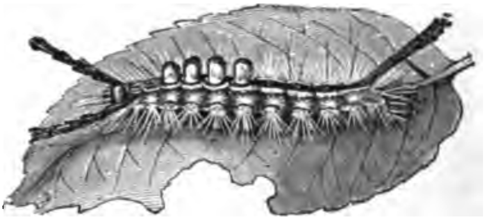

Fig. 8. White-marked Tussock-moth, *Hemerocampa leucostigma*, larva. Natural size.

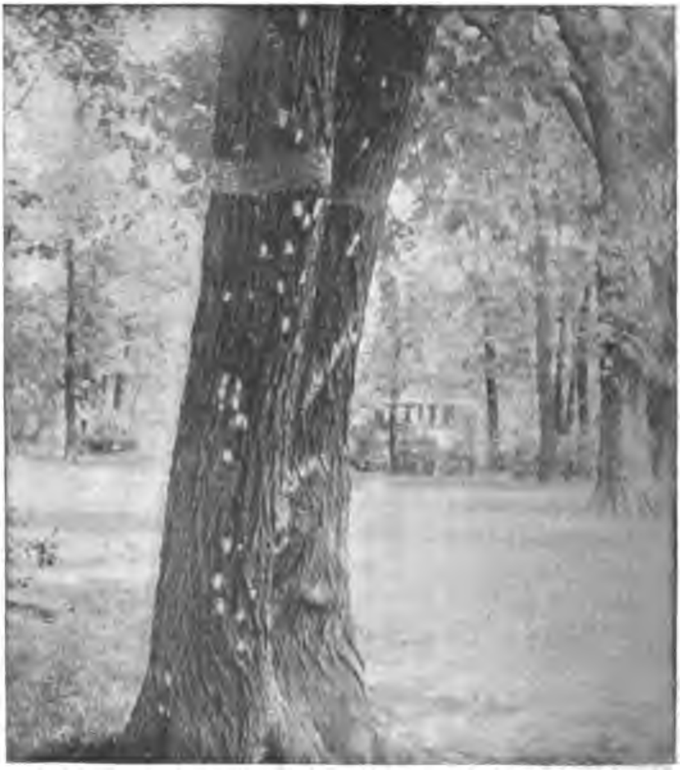

Fig. 9. White-marked Tussock-moth, *Hemerocampa leucostigma*, cocoons and egg masses on tree trunk in a park in Chicago.

spins, on the tree, a delicate grayish cocoon of silken web mixed with its own long hairs. It changes to a pupa within a few hours after the cocoon is finished and continues in this condition from ten days to two weeks.

The adults are moths, the females (Fig. 10) of which differ very widely from the males (Fig. 11) in the fact that they are almost absolutely wingless. The males have good wings and at least the average power of flight. They are of an ashy gray color, with dark wavy bands across the fore wings, a small black spot on the outer edge near the tip, a blackish stripe beyond this, and a minute white crescent near the hind angle. The wings, when expanded, measure about one and a fourth inches across. The female has little of the appearance of a moth, her wings being reduced to the merest rudiments. Her thick, oblong-oval body is of a light gray color, with rather long legs, and is distended with eggs. When she comes out she lays her egg mass on the cocoon from which she emerged—a fact which makes it plain that the species can spread only by way of the wandering caterpillars, or by the transportation of egg masses on young trees. The eggs of the last generation are ordinarily produced in September and the winter is passed in this condition.

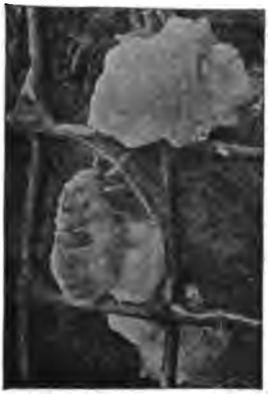

Fig. 10. White-marked Tussock-moth, *Hemerocampa leucostigma*, female and egg masses. Natural size. (Connecticut Experiment Station.)

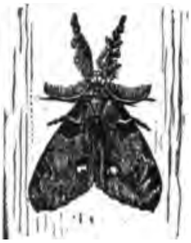

Fig. 11. White-marked Tussock-moth, *Hemerocampa leucostigma*, male. Natural size.

Many insect parasites infest the pupa and do much towards holding the species in check. They are not usually abundant enough, however, to control it completely. In the fall of 1907, for example, one of my assistants reported that 75 percent of the cocoons of the tussock-moth in the Chicago parks were parasitized, but the caterpillars were nevertheless very numerous and destructive the following year. Birds eat them, but not freely enough in the larger cities to reduce their numbers materially.

Three measures of destruction are applicable to this pest and sufficient for its control. These are the destruction of the egg masses in winter, banding trunks of uninfested trees in spring, and spraying infested trees in summer. The trunks and larger branches of trees, as well as all objects surrounding those infested the season before, should be carefully examined in winter and spring for egg masses, and all these within reach should be scraped or cut away and burned or otherwise destroyed. Those beyond convenient reach may be killed in place by touching each egg mass with a sponge or brush attached to the end of a long pole and dipped in crude creosote.

As the insect spreads from tree to tree only in the caterpillar stage, an uninfested tree may usually be protected completely by banding the trunk in such a way that the caterpillars from adjacent trees can not climb beyond the band. Sometimes, however, the branches of trees intermingle or touch in such a way that the caterpillars may go from one tree to the other without coming down to the ground. These bands should be applied to the tree soon after the caterpillars begin to appear in spring, and they should be renewed from time to time as they are made useless by exposure to the weather.

Either one of two kinds of bands may be used. The trunk may be surrounded, at a convenient height, by a belt nine inches wide of what is known as tree tanglefoot, applied with a brush; or bands of cotton batting about four inches wide may be tied closely about the tree by a string passed around the middle of the band, the upper half of which should then be turned down over it.

Where the preceding measures have been neglected and trees are being defoliated, the injury may be stopped by spraying with Paris green or arsenate of lead. This, however, is a difficult and somewhat expensive operation with large trees, and may be rendered unnecessary by destroying the egg masses and banding the trees as above described.

THE BROWN-TAIL AND GYPSY MOTHS

(*Euproctis chrysorrhœa* Linn. and *Porthetria dispar* Linn.)

These two frightful insect pests, altho present in America, the first for about forty years and the second for nearly half as long, have neither of them become established in Illinois, or indeed made any permanent appearance outside of New England. It will probably be long before the gypsy moth becomes an inhabitant of this state, its powers of migration being limited to the larva. The female, altho well provided with wings, has a very heavy body, and does not fly. The brown-tail moth, on the other hand, is a strong, swift flier, and is virtually certain to occupy the whole country in due time, and it is further particularly likely to be introduced into the state direct from its European habitat on nursery stock imported from France. It winters in the caterpillar stage partly grown, hundreds of young collecting in single colonies on the trees, where they hibernate in closely webbed nests (Fig. 12). Hundreds of these nests containing living young were sent, in 1909, into Illinois from France, and only the most active and fortunate inspection work prevented their escape in this state that winter. Worse than this, however, infested cases of nursery stock originating in France were reshipped into Illinois from other states where the force of inspectors was not sufficient to deal with the shipments arriving, and danger from these sources will continue year after year unless other states strengthen their inspection systems. Furthermore, since stock received in Iowa was shipped to this state that winter bearing living brown-tail caterpillars, it is extremely likely that the part retained in Iowa was similarly infested and that the brown-tail has thus obtained a lodgment there and possibly in other states adjacent to Illinois. If this is the case it will presently spread to our state also, especially as the moth flies long distances before the prevailing winds. It is important, for these rea-

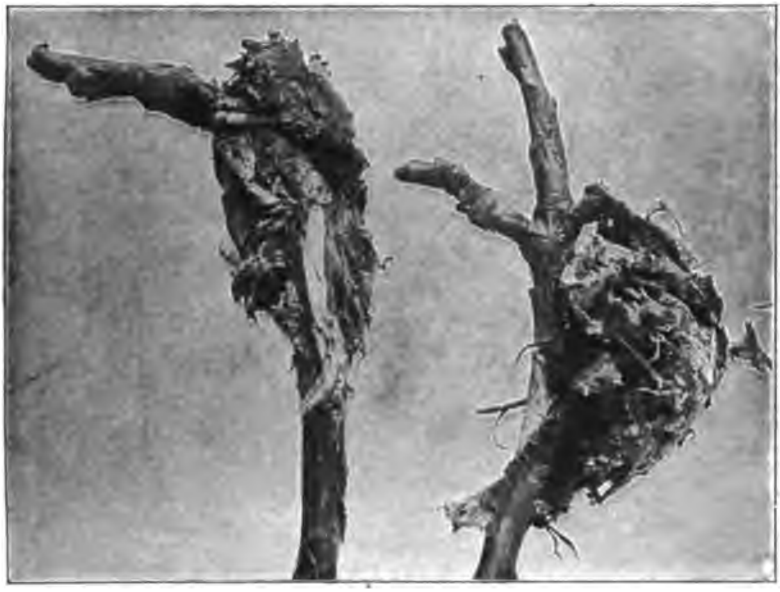

Fig. 12. Brown-tail Moth, *Euproctis chrysorrhœa*, winter nests. Natural size. (Connecticut Experiment Station.)

sons, that our people should be fully informed and carefully instructed in advance in order that the first of these insects to appear may be detected and destroyed without delay.

The brown-tail moth is a caterpillar (Fig. 13) in the destructive stage, and, of course, goes thru the four stages of egg, larva, pupa, and adult. It is easily distinguished in the last of these stages from any American insect by the character to which it owes its name of "brown-tail," namely, a thick brushlike tuft of orange-brown hairs at the tip of the abdomen, especially in the female (Fig. 14). Otherwise both sexes are pure white thruout, except that occasionally there may be a few black spots on the fore wing of the male. They measure about an inch and a quarter from tip to tip of the expanded wings. Any pure white moth of approximately this size with an orange-brown tuft of hairs at the tip of the abdomen may be at once set down as the brown-tail; and any one seeing it in Illinois will render a notable public service by reporting the fact promptly to the State Entomologist, at Urbana, Ill.

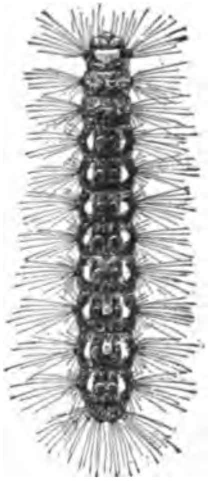

Fig. 13. Brown-tail Moth, *Euproctis chrysorrhœa*, larva. Natural size. (Massachusetts Experiment Station.)

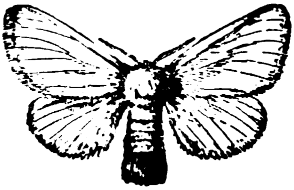

Fig. 14. Brown-tail Moth, *Euproctis chrysorrhœa*. Slightly enlarged. (Massachusetts Experiment Station.)

The winter nests of these caterpillars are also easily identified, since no native Illinois species hibernates on either tree or shrub in colonies of living caterpillars inclosed in a web. Any such cluster of young caterpillars so protected by a common web may consequently be set down at once as the brown-tail and should, of course, be promptly destroyed and the facts reported to the Entomologist. Nurserymen importing European seedling stock can not guard too carefully against the accidental importation of this insect pest, as it is widespread in Europe, breeding abundantly on hedges, trees, and various shrubs, and making its way into the nursery from infested surroundings.

The brown-tail feeds upon practically all deciduous trees and many shrubs and even upon herbs. Thousands of fruit trees in the vicinity of Boston have been killed by it, and damage to maples and elms in wooded regions has caused the forest to appear brown in June, an injury which, if repeated for three or four years, has killed many trees. As the caterpillars pass the winter about a quarter grown, they begin to devour the leaves of trees as soon as these put out in spring, and even eat the buds and blossoms before the leaves have spread. Old trees may thus lose all their buds, or, if not, the foliage itself may be devoured at a later date.

The caterpillar reaches its full size in New England during the last half of June, and the moths emerging, fly about and lay their eggs some twenty days later. The small round eggs are laid in brownish masses (Fig. 15) on the under side of leaves, each mass two-thirds of an inch long by a fourth of an inch wide, and containing about three hundred eggs. The full-grown caterpillar is about two inches long, reddish-brown, with an interrupted white stripe on each side and two red dots on the back near the hind end. It is also blotched with orange and is covered with tubercles bearing long barbed hairs, those on the back and sides with short brown hairs additional, which give them, when magnified, a velvetlike look. The young hibernating larvæ are blackish, with reddish-black hairs and black heads. The pupa is formed among the leaves on the infested tree or shrub, most frequently at the tips of the branches, where several caterpillars may spin a loose web together, each forming, how-

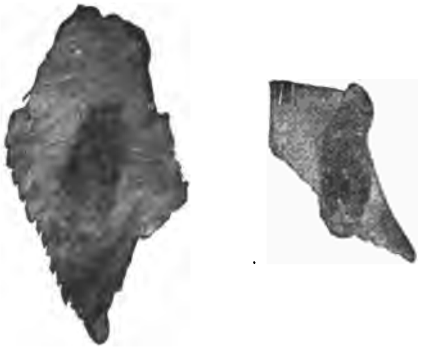

Fig. 15. Brown-tail moth, *Euproctis chrysorrhœa*, egg masses on leaves. Natural size. (Connecticut Experiment Station.)

ever, its own cocoon within the web. When the insect becomes abundant, cocoons may be found under fences and at the edge of clapboards on houses, and in many similar places.

One of the most disturbing peculiarities of a brown-tail infestation is the fact that the long barbed hairs already mentioned are covered with a poisonous excretion, and that they readily pierce the skin, causing an irritating rash which occasionally results in serious illness. "Indeed," says Dr. Howard, "it is not necessary for the caterpillar itself to come in contact with the skin; at certain times of the year it seems as though the hairs were actually floating about in the air. At the time of the caterpillar's change of skin, and particularly at the time of the spinning of the cocoon and the final change, certain of these hairs appear to become loosened in such a way that they are carried by the wind." Others report that these poisoned hairs may collect on clothing hanging on the line, to the intense annoyance of those who wear it.

The readiest and most obvious means of controlling the brown-tail moth, and certainly the easiest one, is the collection and destruction of the winter nests after the leaves have fallen. After April the only practical remedy is spraying the trees with an arsenical mixture. The young caterpillars are readily enough destroyed with arsenate of lead, but the older ones become resistant to poison sprays, and as much as five pounds of the arsenate to a barrel of water has been found necessary to kill the full-grown caterpillar.

When this insect appears within our borders it will be most destructive in parks and towns and forest plantations, since these are not regularly sprayed and will require a special treatment to protect them. It will also aid the San Jose scale in putting out of business the neglectful or indifferent orchardist, but the business fruit grower, who values his property and takes care of it as well as he can, will have much less to fear from this insect, since his ordinary spraying operations will be practically certain to destroy it as it enters his orchard. The fact, however, that the full-grown caterpillar requires a heavier insecticide treatment than does the codling-moth and the canker-worm, for which most of our spraying is done, may make it necessary to go over the orchard in winter to remove and destroy the hibernating colonies.

The gypsy moth may be more briefly considered, altho it is even a more destructive pest than the brown-tail, especially for the reason that it eats the leaves of evergreens—trees which are often killed by a single defoliation. It is conveyed to distances in the caterpillar stage only by accident. Passing wagons, automobiles, trolley cars, or even railroad trains, may carry the caterpillars to uninfested districts, but in this way its spread is slow, especially as all possible measures are being taken in infested districts of New England to keep the roadsides free from the pest, and thus to reduce to a minimum the possibility of an extensive spread.

The caterpillar of the gypsy moth (Fig. 16) is a voracious feeder, eating the leaves of nearly every kind of tree or shrub, and devouring sometimes also grasses and field and garden crops. The very fact that it spreads but slowly makes it locally all the more injurious, since it accumulates in enormous numbers upon infested localities. Forests, orchards, gardens, parks, and street shrubs and trees may be stripped of every leaf between the first of May and the middle of July.

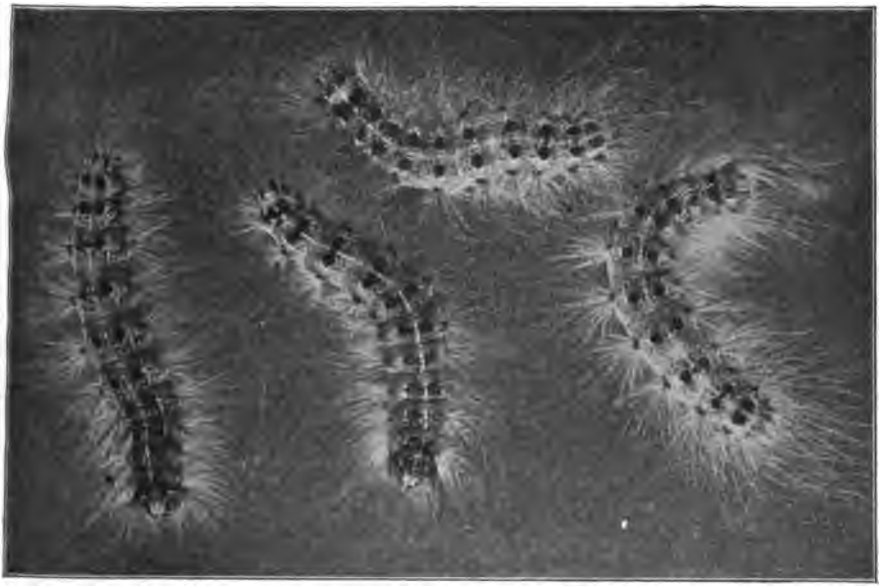

Fig. 16. Gypsy Moth, *Porthetria dispar*, larvæ. Natural size. (Connecticut Experiment Station.)

The insect winters in the egg stage, the eggs being plastered in conspicuous masses (Fig. 17) on the trunks of trees and on various other objects. They may readily be destroyed by touching them with a mixture of creosote oil, 50 percent, carbolic acid, 20 percent, turpentine, 20 percent, and coal-tar, 10 percent, in sufficient quantity to soak the mass. The caterpillar may also be killed on the trees with arsenical poisons, but these must be applied in unusual quantities, since the gypsy moth is not readily poisoned in the caterpillar stage. Five pounds of arsenate of lead to fifty gallons of water will kill the young, but even this can not be depended upon for the full-grown caterpillars. These are about three inches long, of a sooty or dark gray color. Along the back is a double row of blue spots, followed by a double row of red spots, and the back is marked with yellow. The cocoon is formed among the leaves like that of the brown-tail and the moths appear from the middle of July to the middle of August. The male is bluish-yellow, expanding about an inch and a half, and the female (Fig. 17) is nearly white, somewhat spotted and barred with black. Its wing expanse is about two and a fourth inches. The female is very sluggish and so heavy that she can not fly; but the male is an active flier.

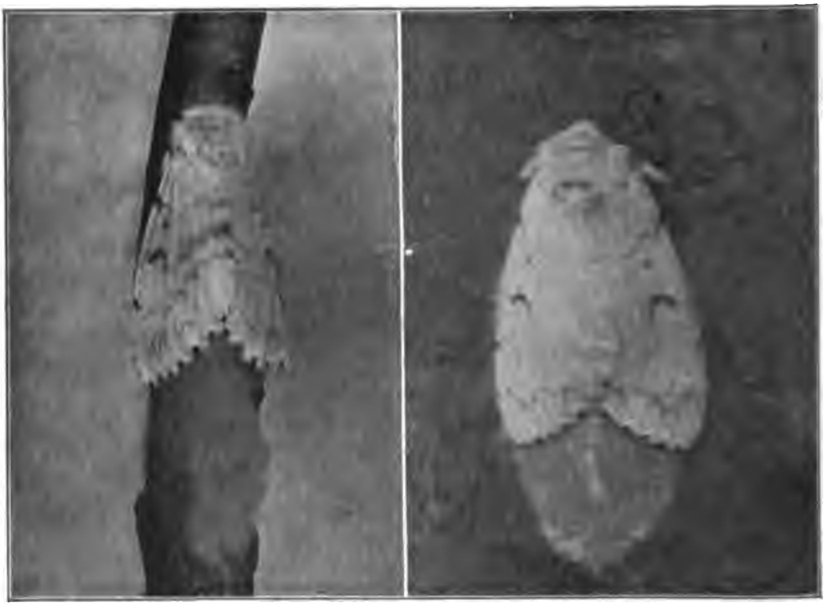

Fig. 17. Gypsy Moth, *Porthetria dispar*: female moths, laying eggs on bark. Natural size. (Connecticut Experiment Station.)

The oval egg masses, about one and a half inches long by three-fourths that in width, are laid in summer on the trunks of trees, on fences, on the sides of houses, and in various other places Large holes in old trees are often found filled with them. The caterpillars feed principally at night, especially after they reach some size, and they seek to hide during the day, often coming down upon the larger limbs and trunk of the infested tree in search of hiding places. This habit has led to the use of bands of burlap tied around the trunks of trees, under which the caterpillars may rest during the day and where they can be easily destroyed by hand.

The probabilities of widespread destruction to forest, park, and orchard properties by these insects are greatly reduced by the truly tremendous and unexampled work being done by the United States Department of Agriculture and the state of Massachusetts in bringing from Europe the native parasites of these insects. This work is making successful progress, and it is all the more hopeful because the parasites of both these species seem to keep them substantially in check in the Old World, where they rarely become seriously destructive.

THE FOREST TENT CATERPILLAR

(*Malacosoma disstria* Hbn.)

There occasionally appears in the forest region of southern Illinois an overwhelming eruption of caterpillars which denude large areas of woodlands, especially the oaks and the maples, and the black and sweet gum trees, and thence invade orchards, parks, and town premises, carrying the same destruction to fruit and shade trees generally. This is one of the species which moves in masses such as actually to delay the passage of railroad trains, piling up

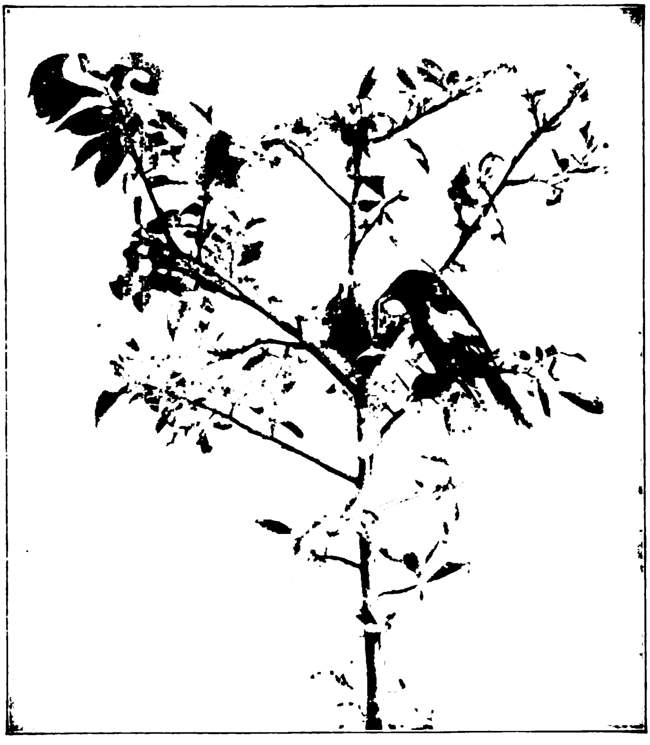

Fig. 18. Baltimore Oriole attacking nest of Forest Tent Caterpillar, *Malacosoma disstria*. (New Hampshire Experiment Station.)

on the rails several inches deep. It is known to entomologists as the forest tent caterpillar, but in the South it is commonly called "the caterpillar" simply. The name of "tent caterpillar" is, in fact, inappropriate for it, since it spins but little and never makes a tent. It is closely allied, however, to the common tent-caterpillar of eastern orchards and has received its common name because of this resemblance.

When full grown (Fig. 19) it is about two inches long and a quarter of an inch thick. It is of a brownish general color, and is conspicuously marked with a series of whitish or cream-colored spots down the middle of the back. On the upper part of each side is a rather broad blue line edged above and below with a yellowish-brown line. When disturbed it drops from the branch and hangs suspended in mid-air by means of a fine thread spun from the mouth. In moving about on the tree these caterpillars follow each other in single file. They feed mostly in the tops of the trees, often eating out the central part of the base of a leaf, allowing the remainder to fall to the ground. When preparing to molt, they mass together on the limbs and may continue thus for a day or two. They often form similar masses in stormy weather and in general when at rest. The eggs (Fig. 20) are laid in a thick hard band around a twig and covered with an impervious varnish. From these the young hatch in early spring, sometimes before the appearance of the leaves on which they depend for food.

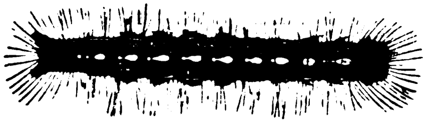

Fig. 19. Forest Tent Caterpillar, *Malacosoma disstria*, larva. Natural size.

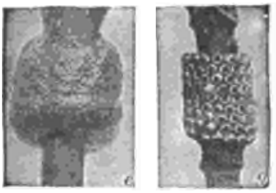

Fig. 20. Forest Tent Caterpillar, *Malacosoma disstria*: *e*, egg ring recently laid; *g*, hatched egg ring. Slightly enlarged. (Cornell Experiment Station.)

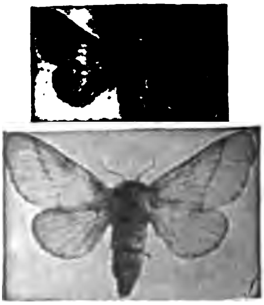

Fig. 21. Forest Tent Caterpillar, *Malacosoma disstria*: *m*, male; *f*, female. Natural size. (Cornell Experiment Station.)

They are capable, however, of fasting for a considerable time without injury, and they may even survive the destruction of the leaves by late frosts. They scatter for pupation late in May or early in June, spinning cocoons which they fasten among clusters of leaves or exposed on fences and in other similar situations. There is but a single generation in a year. The parent moths (Fig. 21) measure about an inch and a quarter across the expanded wings. The general color is brownish-yellow and the fore wings are marked by two straight dark brown lines which cross them obliquely, parallel with each other and the hinder edge.

Trees may be protected by spraying with arsenical poisons shortly after the young caterpillars begin to appear, or by clipping off in winter the twigs bearing the conspicuous belts of eggs and destroying these by burning. Even overwhelming hordes may be arrested by surrounding the tree trunk with a band of cotton batting about four inches wide, tied around the middle with a string, the upper part being then turned downward over the string. Or, the trunk may be surrounded with a band of printers' ink applied as described in the article concerning the common canker-worm (p. 488).

THE COMMON CANKER-WORM, OR SPRING CANKER-WORM

(*Paleacrita vernata* Peck)

The common canker-worm is best known as a pest of the apple orchard, but it is sometimes even more destructive to elms (Fig. 22) than to apple-trees. It feeds also on cherry, at first eating small holes thru the leaves, but when larger devouring the whole leaf except the midrib and some of the coarser veins. Modern methods of orchard management require a regular and frequent spraying with arsenical poisons as a protection of fruit against the codling-moth, and this has the incidental effect—often unnoticed by the orchardist—of speedily killing off any colony of canker-worms which may have chanced to make a start in the orchard. Hence it is only neglected orchards, or those not in bearing either because too young or by reason of a crop failure for the year, which are liable to serious canker-worm injury.

With the elm, however, the case is different. The canker-worm lives on this tree as willingly and successfully as on the apple. Elms are rarely sprayed in Illinois, and if the canker-worm once comes to infest them there is no natural end to the injury except the death of the tree, unless, indeed, the parasites of the insect and other natural checks on its increase may happily suppress it before that event.

The spraying of large elms is, of course, a difficult and expensive operation, and canker-worms are less susceptible to arsenical poisons than many other insects. There is, however, a much cheaper and more convenient method of protecting the elm, by which advantage is taken of two features in the economy of the insect. When the caterpillars are full grown they leave the tree to pupate in the earth, and the female moth emerging, being wholly without wings, can only reach the tree to lay her eggs by climbing up the trunk. If this is encircled at the proper time by a sticky band impassable by her or by young canker-worms just hatched from the egg, the tree is virtually secure against canker-worm injury except as worms may reach it from neglected trees with which its own branches interlace.

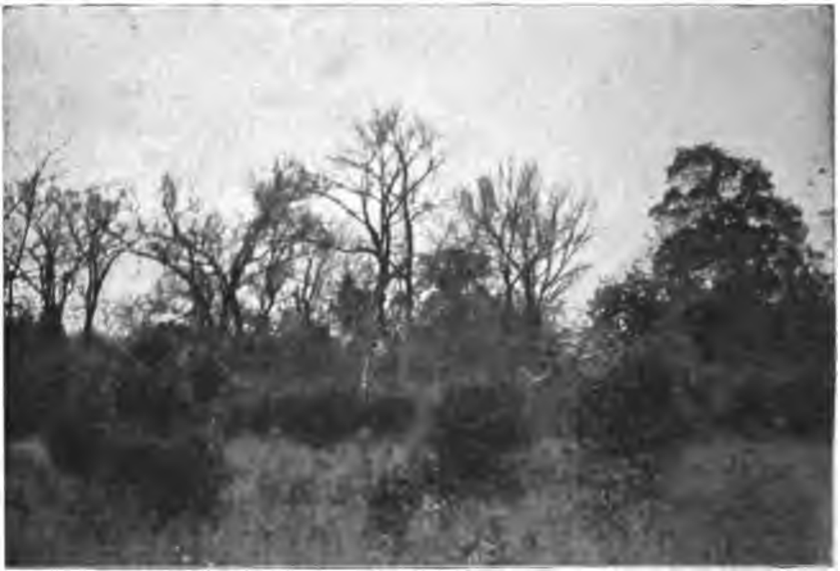

Fig. 22. Injury to elms at Calamus Lake, Niantic, Illinois, by common Canker-worm (*Paleacrita vernata*).

Altho the female canker-worm (Fig. 23, *b*) is wingless, the male (Fig. 23, *a*) has two pairs of rather large, thin, ashy or brownish-gray wings, the first pair with a broken whitish band near the outer edge and three interrupted brownish lines between that and the body. There is also a short oblique black mark near the tip of the wing, and a black line at its edge at the base of a fringe of hairs. The eggs (Fig. 24, *b*) are about .03 of an inch long, oval in outline, and of a pearly luster at first, changing to yellowish-green with a golden, greenish, or purplish iridescence. They are laid in irregular masses, often as many as a hundred together, and usually hidden in crevices of the bark of trees.

The female comes out of the ground to lay her eggs from February to April, the date varying with the latitude and the season. The young caterpillars appear about the time that the apple-tree unfolds its leaves, commonly, in this state, in April or early May, and they usually get their growth in about a month from the time when they issue from the eggs. They then go into the ground to a depth of two to five inches, each one in a small cell, where they change to the chrysalis, remaining there until the following winter or early spring, when the change to the adult insect takes place. There is thus but a single generation produced each year. The canker-worm is widely distributed thruout the country and may occur in destructive numbers in any part of Illinois. Its feeble power of locomotion prevents its rapid spread in any locality, but by concentration of its injuries it is the more destructive where it does occur.

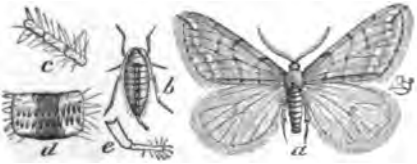

Fig. 23. Common Canker-worm, *Paleacrita vernata:* a, adult male; b, female; c, portion of female antenna; d, joint of abdomen, enlarged; e, ovipositor.

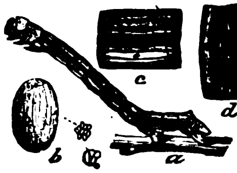

Fig. 24. Common Canker-worm, *Paleacrita vernata:* a, larva; b, cluster of eggs, natural size, with one enlarged; c, side view of one of the segments, d, back view of same, both enlarged.

In its injurious or caterpillar stage (Fig. 24, *a*) it is readily recognized. It has a long and slender form and the habit of a "looper" or measuring worm. When not eating it usually adheres only by its hinder prolegs, extending the body from this point of support at an angle of about 45 degrees. As it is colored much like the bark of a tree, it then has the appearance of a stubbed twig. It also has the habit of spinning down from the tree at the end of a thread, particularly if the branch is jarred or shaken. Both the just-mentioned habits are doubtless advantageous to it; the first by concealing it to some degree from the observation of birds and the second by putting it beyond their reach. The full-grown canker-worm is about nine-tenths of an inch in length and may vary from greenish-yellow or gray to dusky or even dark brown, with paler stripes along the sides. A close examination will show also two light lines running close together along the middle of the back.

The young are usually olive-green. The wingless female, with its small gray body from a quarter to two-fifths of an inch in length and its rather long legs, gives more the impression of a spider than that of a moth. The chrysalis is pale grayish-brown, with a dark green tinge on the wing sheaths, and measures about a third of an inch in length.

This insect has not recently been abundant in Chicago, but its capacities for injury are well illustrated in a recent attack on elms at Big Rock, Kane county. Some ten years ago it was generally prevalent thruout the south-central part of the state, both in towns and in forests, to which it had apparently escaped from neglected orchards, although in some cases orchards were invaded in turn from adjacent forests. A most threatening attack was made on the magnificent old elms of Jacksonville, but a vigorous campaign, first of spraying and later of the application of adhesive bands, presently brought the outbreak under control.*

A cheap and available band for the trunk of a tree is made by laying around the trunk first a strip of unglazed cotton batting two or three inches wide and over this a four- to six-inch strip of tarred paper tied around the middle with ordinary wrapping twine. Upon this paper belt should be spread a layer a quarter of an inch thick of cheap printers' ink with which a small amount of car wheel oil has been mixed, just enough to make it easy to spread. If the tarred belt becomes slightly hardened by exposure so as to permit an insect to cross, it may be made sticky again by brushing it with a little of the same kind of oil. The cotton batting beneath the paper is necessary to keep the young canker-worms or the female moths from crawling up behind the paper where the roughness of the bark would give them passageway. These bands should be placed on the tree as early as the middle of February or the first of March, the time varying according to the latitude, and they may be safely removed by the middle of June. The cost of the bands will approximate ten cents a tree.

If the canker-worms have already ascended the tree, it is sometimes necessary to spray the leaves with an arsenical poison, which may be either arsenate of lead or Paris green, the latter at the rate of one pound of the poison and one pound of lime to seventy-five gallons of water. If the arsenate of lead is used, three pounds of it dissolved in fifty gallons of water will kill even the full-grown caterpillars.

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*The Canker-worm on Shade and Forest Trees. By S. A. Forbes. Twenty-second Report State Ent. Ill., page 139.

THE LILAC BORER

(*Podosesia syringæ* Harris)

Among the borers whose instincts lead the female to choose, for the deposit of her eggs, scars or injured places on the bark of trees and shrubs, with the effect greatly to increase the injury and to prevent its healing, is a species commonly known as the lilac borer (*Podosesia syringæ*), because it was first noticed to infest lilacs. It is much more important, however, by reason of its injuries to various species of true ashes,* and to the mountain ash,

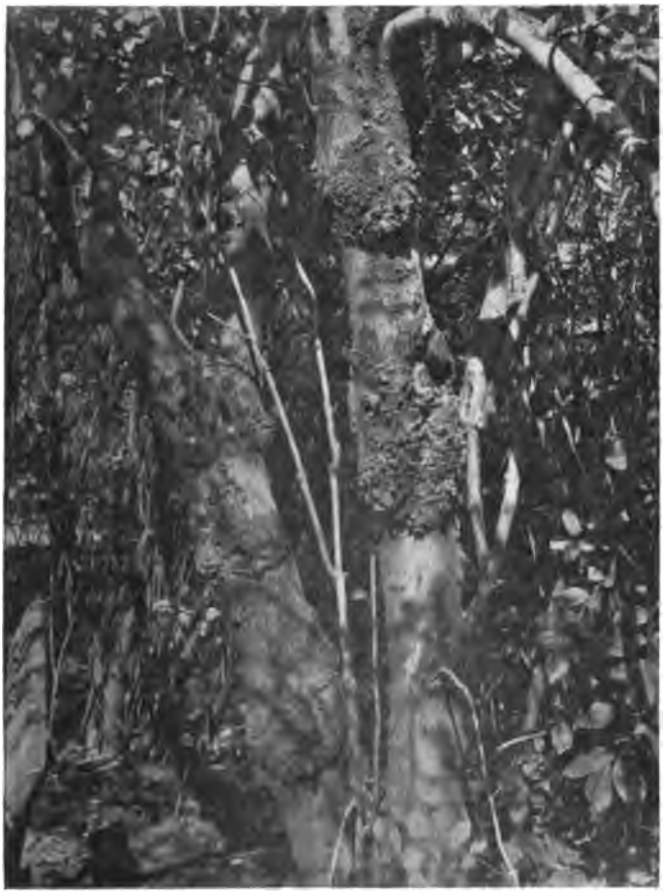

Fig. 25: Trunk of ash in one of the parks in Chicago, showing injury by the Lilac Borer, *Podosesia syringæ*.

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*It has been found injurious to the lilac (*Syringa* sp.), to the mountain ash (*Sorbus americana*), and to the white, green, and English ashes (*Fraxinus americana, lanceolata,* and *excelsior*).

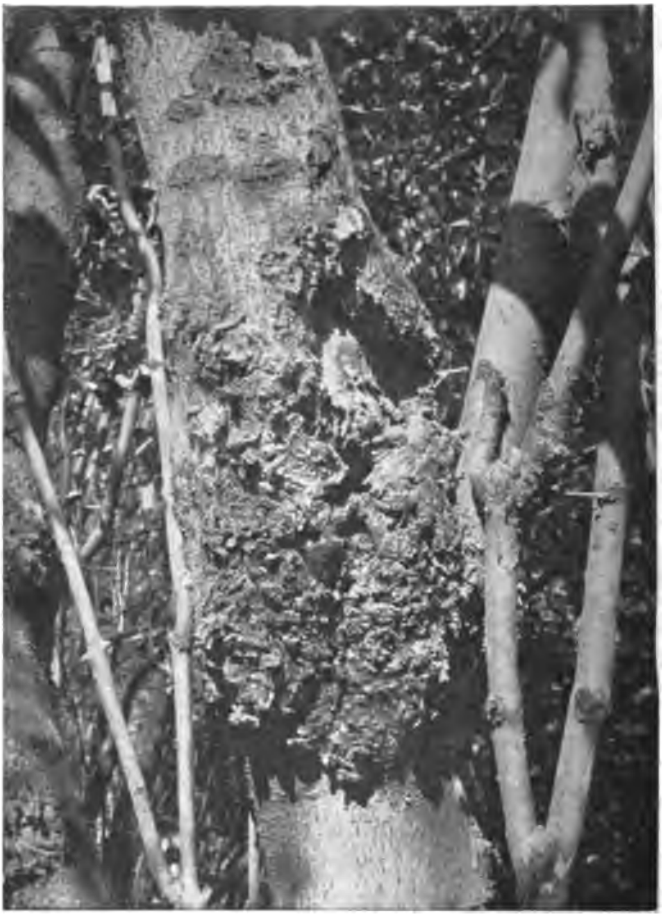

Fig. 26. Trunk of ash, in one of the parks in Chicago, showing injury by the Lilac Borer, *Podosesia syringæ*.

on the trunks and branches of which it produces large, rough, scar-like outgrowths from knots, roughened places, or wounds, by undermining the bark and boring into the wood. (See figures 25 and 26.)

The eggs are laid in summer in masses on rough, scarred, or knotty places. They hatch in about six days and the young borers eat thru the bark into the outer layers of the sapwood, where they mine irregularly about, penetrating the harder wood and going to the center of small branches. (Fig. 27.) In fall, when they are nearly or quite full grown, they make a hibernating cell by plugging up the burrow both before and behind with frass, and there they pass the winter as larvæ. They do practically no burrowing in spring, but pupate in April or the first part of May. As a preparation for pupation, they burrow outward and cut their way thru the bark, leaving only a thin outer film to close the pupal cavity. By means of short teeth with which each segment of the abdomen is armed, the pupa, when mature, works its way out of its gallery until it projects some three-quarters of an inch. The winged insects, altho moths, closely resemble wasps in movement, color, and form. They make their appearance from the latter part of April to the middle of June in central and northern Illinois.

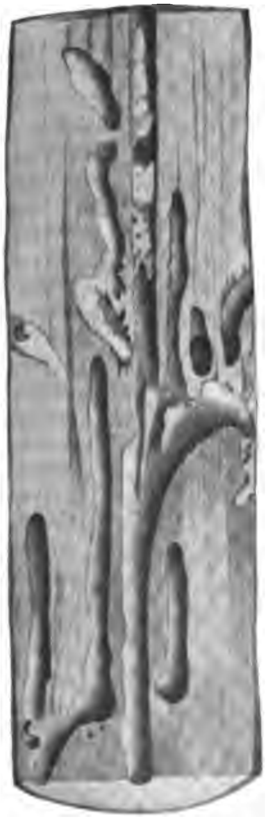

Fig. 27. Lilac Borer, *Podosesia syringæ*. Burrows in ash made by larvæ. Slightly reduced.

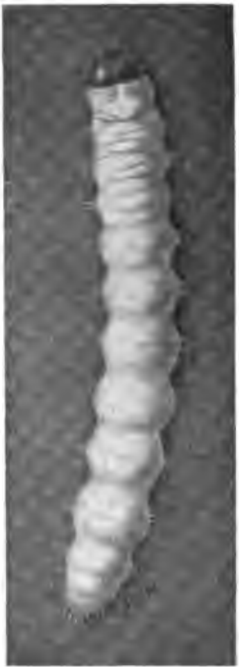

Fig. 28. Lilac Borer, *Podosesia syringæ*, larva. About 5 times natural size.

The borer or larva (Fig. 28) is very variable in length. It is white, yellowish anteriorly, the head of a bright mahogany color, becoming very dark at the mandibles, which are stout, broad, and provided with five teeth. The segments of the body are distinctly marked, somewhat flattened, the first segment reddish and leathery above, the last with a broad yellowish patch.

The moth (Fig. 29) has a black head, a deep brown thorax more or less marked with bright chestnut-red, and a black abdomen sometimes marked with chestnut, but sometimes with a small yellow spot on each side of the fourth segment, or with the segments banded with yellow. The femora are black, the anterior pair of the tibiæ orange, the middle and hind tibiæ black with orange bands. The tarsi are yellow, the hind pair with a black band above. The fore wings are deep brown, with a violaceous luster and usually with a rusty red dash on the outer part. At the base is a transparent streak. The hind wings are transparent and yellowish, the veins, discal marks, and margins deep brown, sometimes tinged with red.

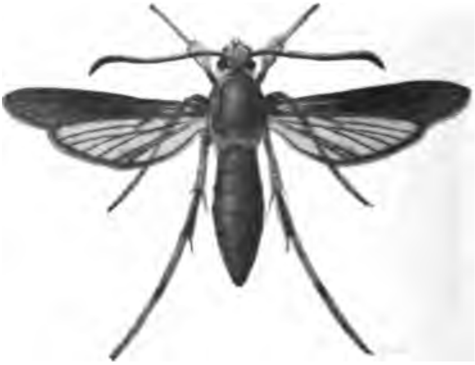

Fig. 29. Lilac Borer, *Podosesia syringæ*, adult. Slightly enlarged.

The spread of the wings is from an inch to nearly an inch and a half, the females being considerably larger than the males.

This insect is very abundant and destructive, especially to the green ash in Chicago parks, and has been bred by us also from the white ash at Kankakee. Its injury is very noticeable and characteristic, especially on the trunks of small trees. Sometimes the smaller branches break off at the point of injury, but this does not usually happen until after the moth has escaped. George D. Hulst says, writing of these insects in New York: "In this section they are very destructive to both lilac and English ash. Large shrubs of lilac are now very rarely seen, and the English ash is being rapidly exterminated. In the latter I have seen the wood completely riddled with the holes made by the larvæ and the entire tree dead."

To check the multiplication of the species and the spread of the injury it will be sufficient to cut away and burn infested branches and trees in winter. It may also be practicable to protect trees especially exposed by painting rough, knotty, and injured places on the bark with a poison mixture commonly used by orchardists to prevent infestation by ordinary borers. A number of substances are available for this purpose, the simplest of which, perhaps, is a mixture of soft soap and soda, with the addition of Paris green. The following is a convenient formula: To a saturated solution of washing soda add soft soap sufficient to make a thick paint, and to each ten gallons of this wash add a pint of crude carbolic acid and half a pound of Paris green. This may be painted thickly upon scarred, roughened, or knotty surfaces in April and early May and renewed as necessary until August.

TWO POPLAR BORERS

(*Memythrus tricinctus* Harris)

(*M. dollii* Neum.)

Two boring caterpillars, similar in appearance, but differing in the larval or boring stage mainly in size, infest poplars in this state to an injurious degree. They are most destructive to young nursery trees, particularly to the balm of Gilead (*Populus candicans*), but the Carolina poplar (*P. deltoides*), Figure 30, is also sometimes badly infested. They are generally present thruout Chicago, often infesting trees which are likewise injured by a boring larva, *Cryptorhynchus lapathi*, discussed on p. 502. They have also been found by us in park and street trees in several Illinois cities and towns from Centralia northward. In the case observed by us in Chicago, the eggs of one of these species, which one we do not know, were deposited July 22, mostly in a crevice of the bark or in the neighborhood of a bud, and young larvæ were first seen July 26, altho some of these had apparently hatched at least a week before. The borers winter in the larval stage in the wood, pupate in spring, and come out as winged moths in June and July—at various dates from June 18 to July 26, if we may judge by results obtained in our insectary. From a willow in Cook county a specimen of *M. tricinctus* was bred which emerged July 2.

The boring larvæ are whitish caterpillars, with brown or yellowish heads and a smooth neck shield. The two species are most easily distinguished by the markings of the head and by the number of hooks on the abdominal legs. In *M. tricinctus* the head is yellowish and mottled with large patches of brown, while the abdominal feet have from eighteen to twenty-two hooks in a row. In *M. dollii*

(Fig. 32) the head is brown with large darker patches on the sides, and a black band or blotch between the antennæ. The abdominal feet have ten to fifteen hooks in each row. Both these species are distinguished from some other borers of their family by the fact that the first segment of the thorax bears two oblique dark marks, approaching each other behind.

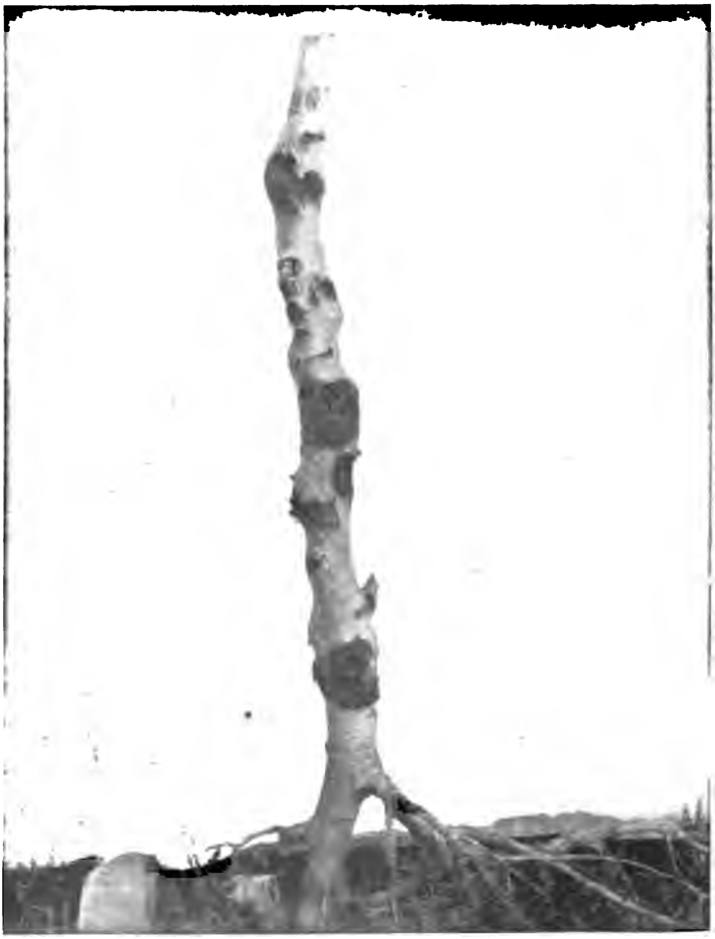

Fig. 30. Small poplar infested with sesiid borers (*Memythrus*).

The winged insects are readily distinguished by a comparison of the wings and abdomens. In *tricinctus* (Fig. 35) the fore wings are violaceous-black, the hind wings are transparent, and the abdomen is black with three or four yellow bands. In *dollii* (Fig. 36) the fore wings are brown, the hind wings are brown and opaque, except at the base, and the abdomen is brown, sometimes with one or more yellow bands.

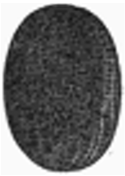

Fig. 31. Poplar Borer, *Memythrus tricinctus* or *dollii*, egg. Greatly enlarged.

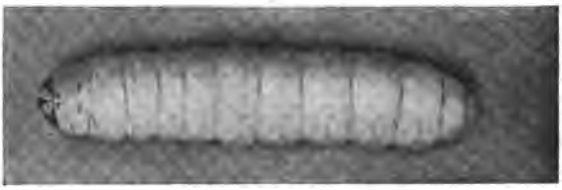

Fig. 32. Poplar Borer, *Memythrus dollii*, larva. About 3 times natural size.

In our work with these borers it was not at first known that two species were concerned, and the larvæ were not distinguished in our notes. It was only when the adults appeared that the specific distinctions were established.

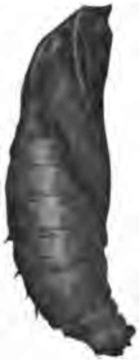

Fig. 33. Poplar Borer, *Memythrus tricinctus* or *M. dollii*, pupa. About 3 times natural size.

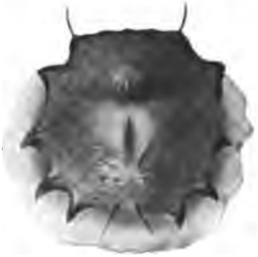

Fig. 34. Poplar Borer, *Memythrus tricinctus* or *M. dollii*, anal end of pupa. Greatly enlarged.

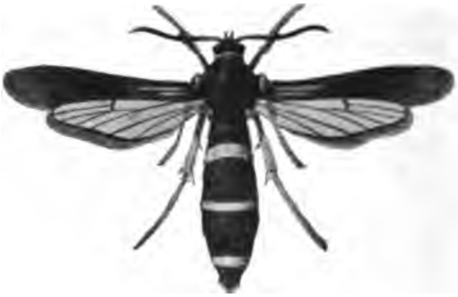

Fig. 35. Poplar Borer, *Memythrus tricinctus*, adult female. About twice natural size.

A third species, allied to the two above mentioned, but more commonly found infesting ninebark (*Opulaster opulifolius*), has been once bred by us from poplar at Chicago.

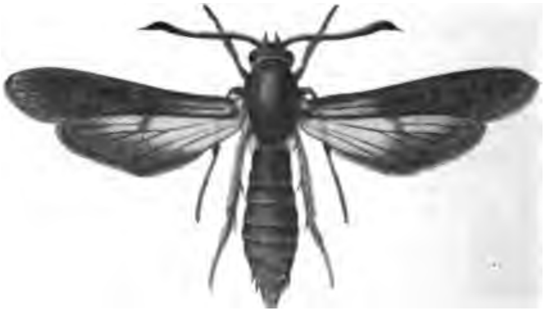

Fig. 36. Poplar Borer, *Memythrus dollii*, adult. About twice natural size.

A VIBURNUM BORER

(*Sesia pictipes* G. & R.)

A boring caterpillar, somewhat larger than that described from ninebark and dogwood, but otherwise extremely similar, has been found doing considerable damage to viburnum shrubs in all the parks of Chicago, and, in one case, to wild black cherry at Riverside. It burrows beneath the bark, frequently killing the branches. It spends the winter in the larval stage, and has emerged in our breeding cages during the latter part of June, from the twentieth to the twenty-fourth. Elsewhere it is reported to emerge during June and July. The species is known also from plum, cherry, beach-plum, peach, Juneberry, and chestnut, and has been bred from the black-knot of the plum.

The placing of the eggs has not been noticed by us, but another observer, Dr. Bailey, found a cluster of them, ninety-two in number, on the under surface of loosened bark a few inches from the root of a badly infested plum-tree.

The removal and destruction of infested branches at the proper time of the year, that is, during the winter and spring, is the only measure practicable for the control of this pest.

The winged insect has a blue-black head, thorax, and abdomen, the thorax with a narrow pale line each side, and the abdomen with a narrow pale yellow ring on the second and fourth segments, encircling the body completely on the latter. The fore wings are transparent, with very narrow blue-black margins, and a narrow, straight, discal mark. The inner margin is sometimes scaled with pale yellow. The hind wings are transparent, with a very narrow outer margin and no discal mark. The spread of the wings is from 15—26 mm., the smaller specimens being males.

THE MAPLE BORER

(*Sesia acerni* Clem.)

The worst of the borers of the maples, both hard and soft, very common and destructive to soft maples in Chicago, and common also in towns thruout the state, is a white or nearly white caterpillar (Fig. 37, *a*) about half an inch long when full grown, with a yellow head and a neck shield of a paler tint. It is especially injurious to young trees, but usually originates in some surface injury which attracts the parent moth in search of a place of deposit for her eggs.

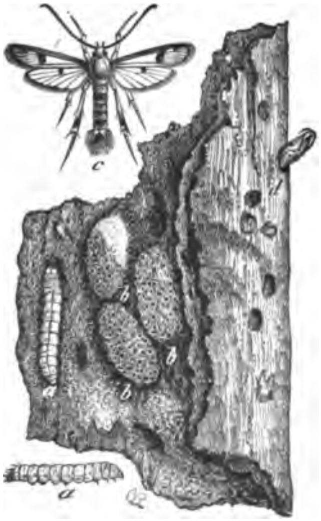

Fig. 37. Maple Borer, *Sesia acerni*: *a*, *a*, larvæ; *b*, *b* *b*, cocoons; *c*, adult; *d*, pupal skin left in mouth of burrow.

It burrows mainly just beneath the bark, where it can be found and destroyed in fall or early spring. It comes to maturity in May or June, eats its way nearly thru the bark, and pupates there. We collected the adult in considerable numbers, at electric lights, in Urbana, from May 18 to June 3, 1887. When ready for its transformation the pupa wriggles partly out of its burrow, and the adult insect escaping leaves the empty pupa-case still sticking in the opening, which is about an eighth of an inch across. (Fig. 37, *d*.)

The adult is a handsome wasplike moth (Fig. 37, *c*; Fig. 38) with thin transparent wings, a slender yellow body banded and trimmed with red, and a brushlike tuft of hairs at the tip of the abdomen. The eggs are laid chiefly in rough or injured places, almost wholly in the trunk of the tree, and not in its branches. The effect of the injury is to kill the bark undermined, and to enlarge surface wounds and prevent their healing, converting them into permanent, rough, and very unsightly scars. Sometimes the tree is killed by a girdling of the trunk.

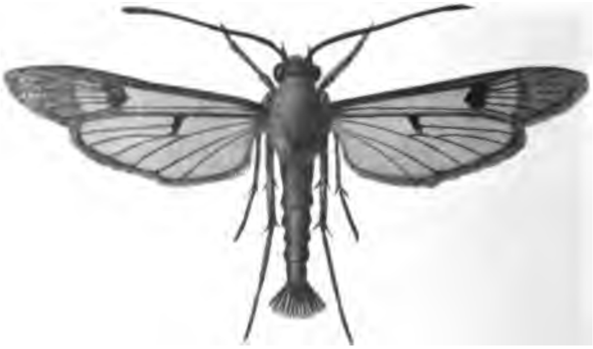

Fig. 38. Maple Borer, *Sesia acerni*, adult. About 3 times natural size.

To prevent attack by these borers the tree should be protected from injury, and such wounds as it receives should be painted over or covered with grafting wax. Dr. Felt, State Entomologist of New York, says that "the deposition of eggs could probably be prevented to considerable extent by treating the trunks of trees about the middle of May with a wash prepared as follows: Thin one gallon of soft soap with an equal amount of hot water and stir in one pint of crude carbolic acid (one-half pint, refined), let it set over night and then add eight gallons of soft water. Apply thoroughly to the trunk, especially about all crevices and wounds, from the ground to about six or eight feet high, and renew if necessary before the middle of June." As the borers work near the surface, they can be easily dug out and destroyed in fall.

THE NINEBARK BORER

(*Sesia scitula* Harris)

Dogwood and ninebark shrubs (*Cornus* sp. and *Opulaster opulifolius*) in the Chicago parks are generally infested, and often seriously injured, by a boring or girdling caterpillar (Fig. 39) which works just beneath the bark, mainly at the junction of the branches or in the neighborhood of an old dormant bud. The burrows of the borer sometimes extend lengthwise of the branch, and sometimes girdle it near its origin. In 1908 nearly every shrub of the ninebark in Washington Park was infested, and many of the branches were killed by this larva. The species also infests the chestnut, and has been bred from galls on twigs of the oak.

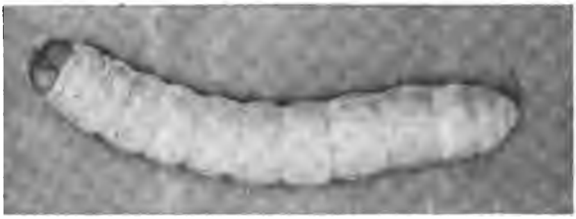

Fig. 39. Ninebark Borer, *Sesia scitula* larva. About 3 times natural size.

The creamy white larva, half an inch long in September, passes the winter in its burrows, and emerges, according to our observations, in late June or in July. The head is brown, darkening almost to black towards the mandibles. The prothorax is slightly brownish, with two oblique brown markings on its posterior half. The remaining segments are creamy white, except the last, which is pale reddish-brown.

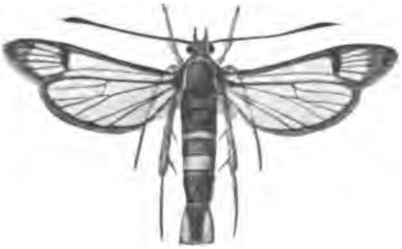

Fig. 4 . Ninebark Borer, *Sesia scitula*, adult female. About 3 times natural size.

The winged insect (Fig. 40) is deep blue-black on the thorax and abdomen, the former with a yellow line and a yellow patch on each side, and the latter with a yellow line at its base and, in the male, a narrow yellow ring on the second and fourth segments, broadening below on the fourth to cover the whole surface. In the female the fourth segment is yellow both above and below. The head and antennæ are black, the femora blue-black, and the tibiæ yellow. The fore wings are transparent, except the borders and the discal mark, which are blue-black. The outer margin is marked with yellow rays. The hind wings are transparent, with very narrow blue-black margins. The spread of the wings is from 18—22 mm.

This insect can evidently best be destroyed by cutting out and burning infested branches in winter or early spring.

THE BAG-WORM

(*Thyridopteryx ephemeræformis* Harris)

One sometimes sees hanging from the branches of trees, in late summer or in fall or winter, especially in the southern part of the state, rough excrescences, about two inches long, shaped somewhat like a spindle full of yarn, soft to the touch, and more or less covered with pieces of dead leaves which seem to be woven into their web-like substance (Fig. 41, *f*). In summer it may be further noticed that these spindle-shaped sacks can creep along the twig, and that there projects from the end nearest the twig the head and front part of a caterpillar, the remainder of which is enclosed in the protecting bag. In winter this is hung to the tree by a rather tough ligament composed of material like spider-web. An examination of these peculiar bodies at that season will show either that they are

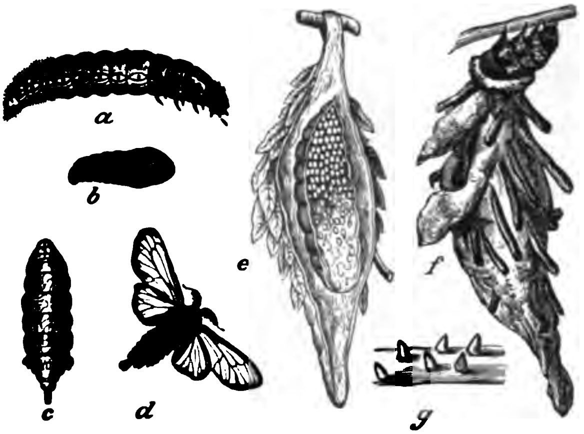

Fig. 41. Bagworm, *Thyridopteryx ephemeræformis*: *a*, larva; *b* and *c*, pupa, side and back views; *d*, adult; *e*, case containing the eggs; *f*, larva in case; *g*, eggs. Natural size.

virtually empty, or that they contain a mass of soft yellow eggs. (Fig. 41, *e*.)

The insect known as the bag-worm, to which these constructions are due, is in several respects one of the most curious in Illinois. Altho the parent form is a moth, the female is wingless and naked (Fig. 41, *c*), looking more like a grub than a moth, and the wings of the male, instead of being covered with scales, are smooth and transparent, somewhat like those of a wasp. (Fig. 41, *d*.) The caterpillar infests a considerable variety of both fruit and shade trees, including among the latter evergreens (especially red cedar and arbor-vitæ, Fig. 42) and several kinds of deciduous trees.

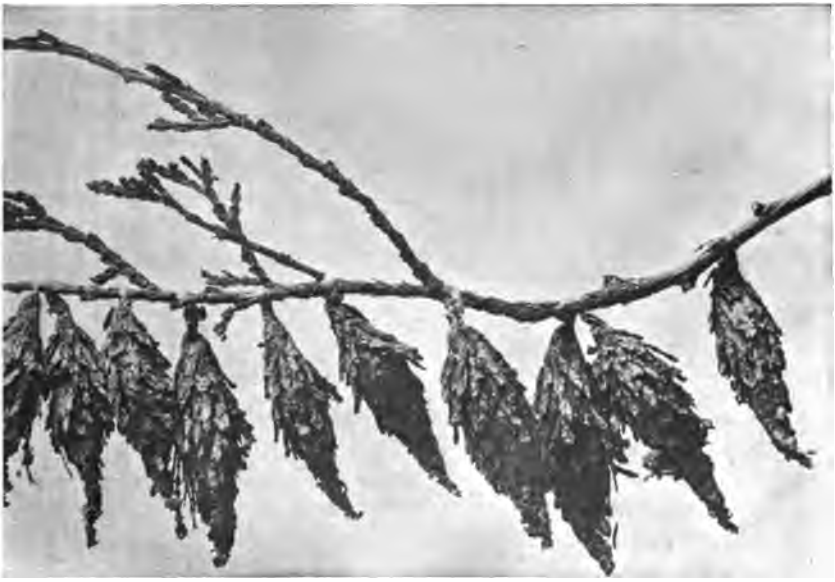

Fig. 42. Bag-worm, *Thyridopteryx ephemeræformis*, cases hanging on arbor-vitæ twig. (Ohio Experiment Station.)

It does its injury by eating the leaves of trees, and its numbers are often such that they may take virtually every leaf off a tree of considerable size.

The eggs, contained during the winter in the bag-like cases on the trees, hatch the following May or June, and the young caterpillars begin at once to spin for themselves small conical cases (Fig. 41, *g*) to which they fasten pieces of leaves from the tree upon which they are feeding. As they grow these cases are enlarged until they take the form and dimensions already described. The caterpillars (Fig. 41, *a*) travel but slowly, and seldom leave the tree upon which they were hatched until they are about full grown, when they are likely to spin down and wander about. They change to the chrysalis (Fig. 41, *b*) within the bags, which they fasten to the twigs of the trees as a preliminary, but the grublike female moth, destitute of wings and with only minute and useless legs, deposits her eggs within her native sack, works her way out of it, drops to the ground exhausted, and dies. The winged males (Fig. 41, *d*) appear in September and October, and soon thereafter the eggs are laid.

The bag-worm is a southern insect in its general range, and is rarely seen in northern Illinois. It increases in importance southward, and in southern Illinois is often a troublesome pest. In a general trip to eighteen towns, well distributed thruout the state, Mr. J. J. Davis, in 1910, found the bag-worm in four out of six southern Illinois towns visited, but in no others.

The simplest method of destroying these insects is to collect the bags during the winter and burn them—a thing easily done with the aid of pruning shears if they can not be reached by hand. If this measure is neglected, infested trees may be cleared by spraying them with arsenical poisons soon after the hatching of the eggs—the latter part of June or early July. A pound of arsenate of lead to forty gallons of water is a safe and effective poison.

THE POPLAR AND WILLOW BORER

(*Cryptorhynchus lapathi* Linn.)

The weeping willow, the Carolina poplar, the balm of Gilead, and the red birch are ornamental trees of sufficient popularity to make the existence of any insect pest destructive to them a matter of general interest. The Carolina poplar especially has had an enormous distribution of late years in Illinois towns, largely because of the ease and certainty with which it may be raised, and the rapidity with which it grows in our soils.

The advent into this country nearly thirty years ago of a European snout-beetle well known in the Old World as a destroyer of alders, poplars, and willows, and occasionally injurious to birches also, has seriously endangered our American plantations of these trees. Detected first in New York in 1882, and found on Staten Island in 1886, it appeared in considerable numbers near Buffalo by 1896, and the following year was reported as abundant in Boston, Mass., and very destructive there to willows and poplars of all kinds, and to the red birch. By 1901 it had reached northeastern Ohio; in 1903 it was found in two Wisconsin nurseries; and in 1904 it was reported from North Dakota in poplars lately brought into that state from New York. In Illinois it was first seen by us in 1908 in Carolina poplars at Chicago; but once detected there it was soon found to be generally distributed and very destructive to both poplars and willows in all parts of the city. (Fig. 43.) It has not yet occurred, to our observation, elsewhere in Illinois. Wherever it appears it multiplies locally, but makes a slow spread, a fact apparently due to the sluggishness of the parent beetle, which, although provided with wings, makes extremely little, if any, use of them. In consequence of this fact, an infested grove may be nearly destroyed before another, near at hand, becomes even infested. It extends its range most readily along watercourses by means of the willows and cottonwoods with which our streams are likely to be fringed. Its spread to distant points seem to have been mainly, if not altogther, by way of the nursery trade, especially that in poplars and willows of various kinds. These facts make it particularly important that

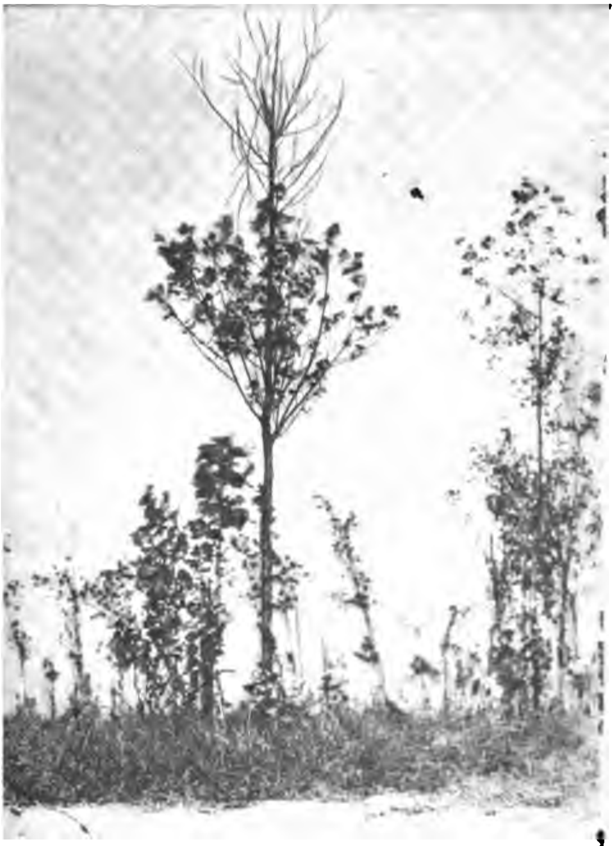

Fig. 43. Small poplar tree in Chicago showing dying of upper branches resulting from attacks of the Poplar and Willow Borer, *Cryptorhynchus lapathi.*

the signs of its presence should be generally known, in order that it may be promptly recognized and suppressed upon its appearance in any new locality.

Injury by this borer may be suspected when the general health of a tree is evidently affected, where there are dead patches of the bark, irregularly cracked open (Fig. 44, 45), or where openings in the bark give exit to a soft excrement like moist sawdust mixed with fine splinters. The burrows beneath the bark, made chiefly in the cambium layer, are irregular in direction, sometimes girdling a small tree, and show nothing of the symmetrical pattern made by many borers which undermine the bark. Those of the older larvæ dip into the wood, usually reaching the center of the branch unless this is large. These deeper burrows finally become filled with powdered wood and splinters, except a chamber at the farther end in which the larva pupates. In the active boring stage these insects are soft, yellowish, fleshy, cylindrical, footless grubs (Fig. 46) with a pale-brown head and darker mouth-parts. They are half an inch long when they reach full size, which is about the last of June for those most advanced. At this time, however, young larvæ may be found under the bark down to a fifth of an inch in length.

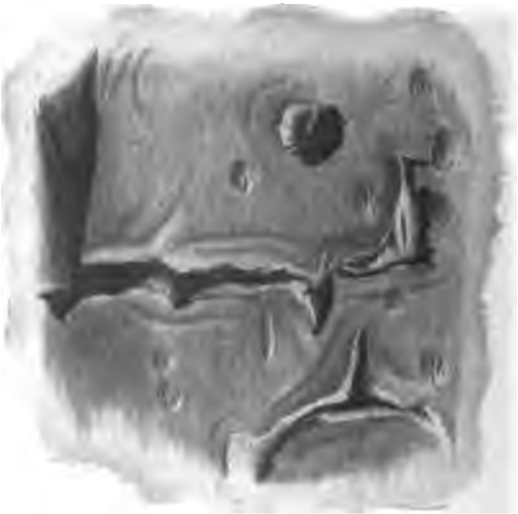

Fig. 44. Injury by Poplar and Willow Borer, ***Cryptorhynchus lapathi.***

The adult beetles (Fig. 47) begin to appear in July, and continue abroad at least until October. They are well marked and easily distinguished insects, a little more than a quarter of an inch long, thick-bodied, with a roughened and punctured surface, and a stout curved beak projecting downward from the head. The general color is dark sooty brown, more or less specked and spotted with gray, and there is a very conspicuous large patch of light gray on the hinder end of the wing-covers, contrasting strongly with the adjacent colors. The sides of the prothorax are gray, and there is a pair of rather definite oblique gray marks just behind the front outer angle of each wing-cover. The beetle is slow and lumbering in its movements, and when disturbed drops to the ground like a curculio, without attempting to fly. It feeds upon the cambium layer of the younger branches, which it reaches by puncturing the bark with its snout. It lays its eggs in the older bark, mainly of branches from two to four years old. This the female does by first eating downward into the bark by means of the jaws at the tip of her snout, taking half an hour or more to hollow out a cavity in which the egg is concealed. She then turns end for end, and leaves an egg in the chamber thus made, and presently moves away to repeat the process at another point.

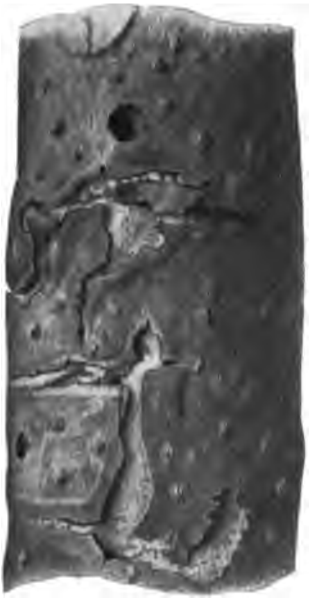

Fig. 45. Injury by Poplar and Willow Borer, *Cryptorhynchus lapathi*.

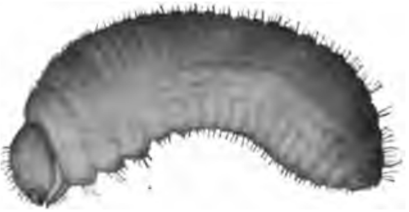

Fig. 46. Poplar and Willow Borer, *Cryptorhynchus lapathi*, larva. About 4 times natural size.

The young hatch mainly in August and September, penetrate at once to the cambium layer, and hibernate there while most of them are still very small. The following spring they continue to work in the cambium until nearly ready for pupation, when they enter older wood.

The dependence of the beetle for food upon the bark of the tree which it infests has suggested the use of poisons for its destruction, and some tests made at the New York Agricultural Experiment Station show that the ordinary arsenical poisons applied as a spray will destroy it. Arsenate of lead is the best of these for the purpose, because of its adhesive quality. Trees to be protected should be thoroly sprayed at intervals of about a fortnight, beginning with the middle of July and continuing thru August. Moderately infested trees may be saved by cutting out the grubs and covering the wound with tar. Badly infested trees should be taken out and burned, either during the winter or before July 1 of the following season. Nursery trees infested by this insect should be unhesitatingly destroyed, since they are far worse than worthless, and are the principal means of conveying the species to places not previously infested by it.

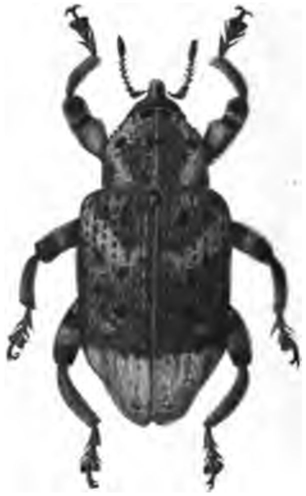

Fig. 47. Poplar and Willow Borer, *Cryptorhynchus lapathi*, adult. Length, about one-fourth inch.

THE DOGWOOD TWIG-GIRDLER

(*Oberea tripunctata* Swederus)

Among the insects whose nice and elaborate instincts connected with the placing of their eggs are the wonder of entomologists, we must class the twig-girdlers, for their careful preliminary operations are such as to suggest a knowledge of vegetable physiology and a prevision of the possible difficulties in the way of the development of their young certainly quite beyond the powers of insect intelligence, and an unsolved puzzle if regarded as a product of natural selection. The twig-girdler of the dogwood is an example.

This is a small, cylindrical beetle (Fig. 48), about half an inch long and less than an eighth of an inch in diameter, which prepares a chosen twig for the reception of the egg by first cutting a groove around it a few inches from its tip in such a way that the twig presently breaks off at this point, and afterwards making a second girdle, not so deep as the first, and from two to four inches farther back. (Fig. 49.) It then makes two parallel cuts, about half an inch long, lengthwise thru the bark between the two girdling incisions, and at the proximal end of these makes a short transverse slit in a way to form an angular flap, beneath which it pushes its egg. The effect of all this surgery must be to stop the growth of that part of the branch operated on, and to check the flow of sap to the section in which the egg is laid.

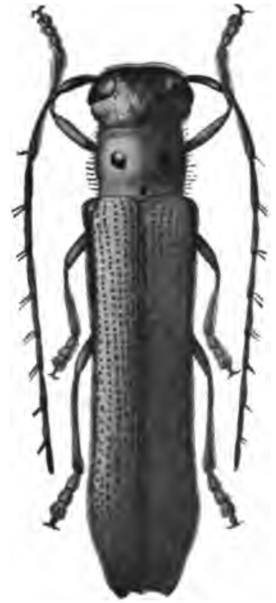

Fig 48. Dogwood Twig-girdler, *Oberea tripunctata*, adult. About 5 times natural size.

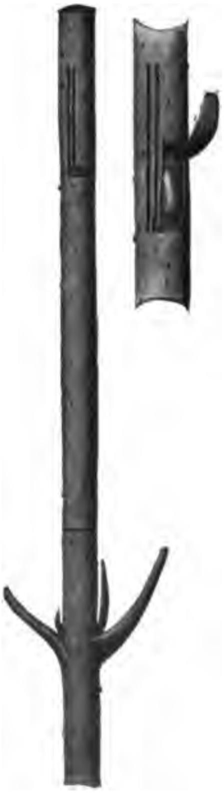

Fig. 49. Cornus twig girdled by Dogwood Twig-girdler, *Oberea tripunctata*, and part enlarged, showing egg in position.

These operations are distributed, in northern Illinois, over the month between the middle of June and the middle of July. The eggs hatch within a week or ten days, and the young larvæ penetrate the twig, burrowing downwards towards its point of attachment, and making holes to the surface at intervals thru which to discharge their excrement. After a time the larva cuts off, from within, the part of the twig thru which it has made its way, and plugs the open end of the burrow with coarse bits of frass. It occasionally repeats this plugging, pursuing its way until winter overtakes it, and pupating within its burrow from the middle to the latter part of the following May, first, however, commonly cutting off the branch obliquely and plugging the cavity a little beyond its pupal cell. (Fig. 50, 51.) The adult emerges during the latter

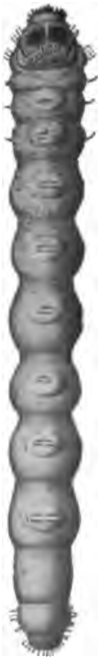

Fig. 50. Dogwood Twig girdler, *Oberea tripunctata*, larva. About 4 times natural size.

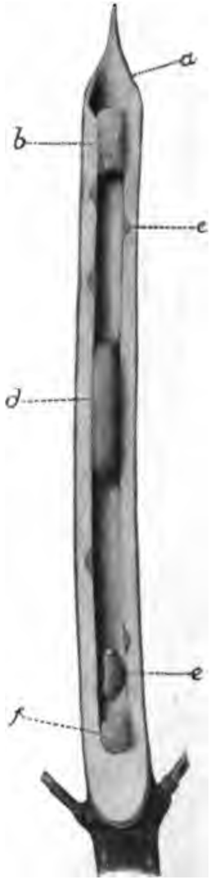

Fig. 51. Cornus twig with burrow of Dogwood Twig-girdler, *Oberea tripunctata*: *a*, end obliquely cut off by larva; *b*, *f*, plugs of frass; *c*, openings made by larva and plugged up later; *d*, cocoon of ichneumoned parasite; *e*, remains of parasitized *Oberea* larva.

half of June, eats its way thru this terminal twig, and feeds during its short life on the leaves of the infested tree, making oval holes thru the leaves along the course of the veins. (Fig. 53.)

The presence of this borer is commonly first betrayed by a withering of the leaves at the tip of the girdled shoots. It is a rather common pest in the Chicago parks, where it has often been abundant enough on the red-osier dogwood (*Cornus sanguinea*) to be decidedly injurious. Like the other small twig-girdlers, this species can best be destroyed by cutting off and destroying the affected branches at a time when they are certain to contain the borer; that is to say, in this case, in any month except June and July.

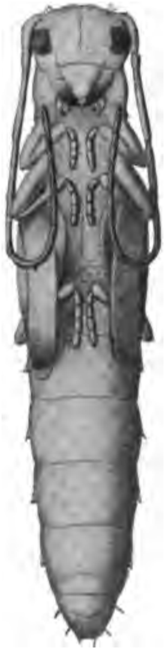

Fig. 52. Dogwood Twig-girdler, *Oberea tripunctata*. pupa. About 2⅓ times natural size.

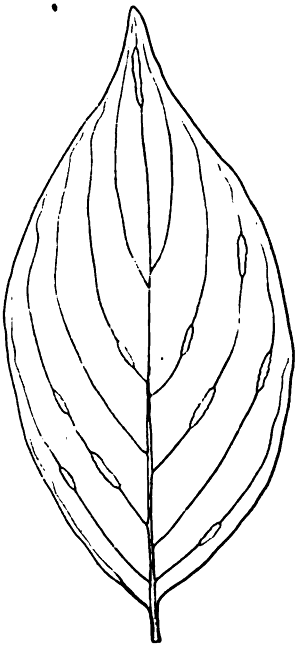

Fig. 53. Cornus leaf injured by feeding of adult Dogwood Twig-girdler, *Oberea tripunctata*.

The various species of this genus have been so imperfectly distinguished that a specific description of this will not be attempted here; but the reader is referred to the illustrations for its general characters. Its larva is much subject to destruction by parasites; and a characteristic parasitic species has been repeatedly bred by us from infested twigs.

THE LOCUST BORER

(*Cyllene robiniæ* Forst.)

A great obstacle to the growth of the common black locust as a timber tree in Illinois has been the work of a borer which infests this tree only, multiplying year after year in a locust grove until it destroys every tree. It was a common practice in the early settlement of the northern part of the state for the farmers to plant a grove of locusts, with a view especially to a supply of fence-posts. These groves were, however, all destroyed by this borer during the middle part of the nineteenth century, and the planting of this tree was universally abandoned at that time. Of course, with the disappearance of the tree the borer likewise disappeared, and the growing of the locust is now again possible if due precautions be taken against its destruction by this insect. Fortunately, the recent work of Dr. A. D. Hopkins, in charge of forest insect investigations for the United States Department of Agriculture, has made it perfectly feasible to grow locusts with little or no loss from this cause, and the following account is mainly taken from his publications on this subject.

The first evidence of attack by this borer in spring is a fine brownish dust and an oozing of sap from the bark. Later, gumlike exudations appear on the injured spots, and quantities of yellowish

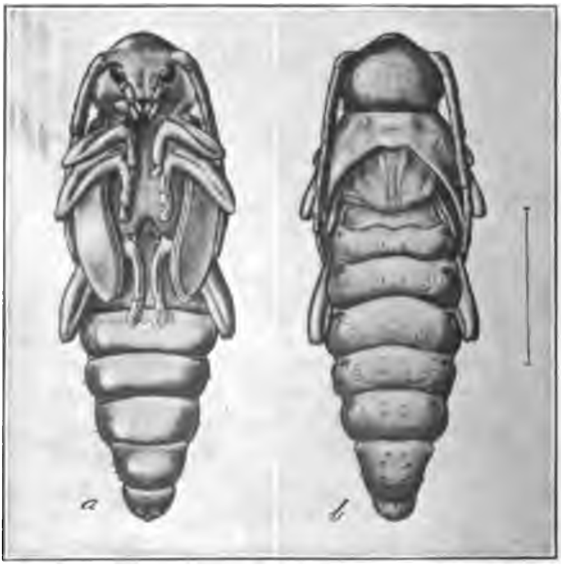

Fig. 54. Locust Borer, *Cyllene robiniæ*, pupa: *a*, front view *b*, back view. Enlarged as indicated. (U. S. Dept. of Agriculture.)

dust lodge in the forks of the tree or branches, and in the loose bark on the trunk and around its base. Badly infested trees show a dwarfed, faded, or sickly foliage about the middle of May, and many of the leaf buds fail to open. The author of this injury is a whitish, thick-bodied, distinctly segmented, seemingly footless grub, nearly an inch long when full grown, with small head, and only a pair of minute feet on the next segment behind. It hatches from eggs laid in crevices of the bark from August to October. The young borers are still very small when the winter overtakes them, and they hibernate in small cavities made by them in the outer bark of the trunk and branches. They commence operations when the sap of the tree begins to flow the following spring, and presently penetrate the wood, burrowing actively about until July or August, in central Illinois, when they begin to change to the pupa (Fig. 54), to emerge about a month later in the beetle stage (Fig. 55).

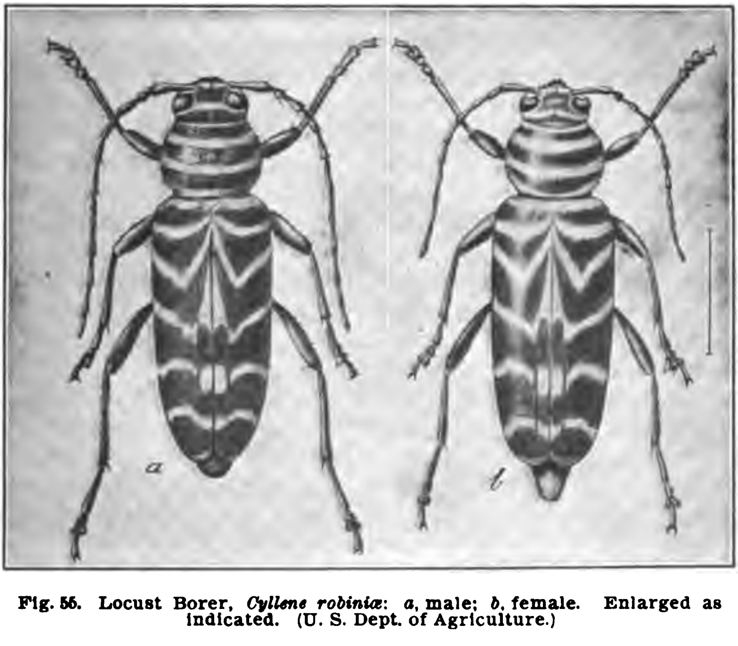

Fig. 55. Locust Borer, *Cyllene robiniæ*: *a*, male; *b*, female. Enlarged as indicated. (U. S. Dept. of Agriculture.)

The adult is a very showy, elongate, brown beetle, five-eighths to three-fourths of an inch in length, conspicuously marked with three straight bands of bright yellow across the thorax and five broken or irregular bands of the same color across the wing-covers. There is also a bright yellow patch on the upper side of the tip of the abdomen. The beetles are to be found in September, and occasionally in early October, on locust-trees, and on various species of goldenrod, upon the flowers of which they feed. Now and then a specimen may survive the winter and be taken abroad in April, or even in May.

From the foregoing statements it is evident that the time of cutting trees, whether to thin the grove or for commercial use, is an important item in the control of this beetle. All such cutting should be done between October 1 and April 1, care being taken that all trees showing the presence of the borer are selected for removal. The bark should then be taken off, and the brush and rubbish should be burned. Simply to kill the larvæ and borers in badly infested and damaged trees, these should be cut and destroyed in May and June, when their condition can be readily detected; but the work should be completed by the time the flowers have all fallen from the trees, as otherwise the borers may mature and escape. Where the beetles are abundant on the goldenrod, they may be attracted and killed, according to Dr. A. D. Hopkins, by smearing molasses poisoned with arsenic upon the trees, due account being taken of the fact that honey-bees are liable to destruction by this poison, and that it should not be used where these are kept. Unsuccessful experiments were made by one of my assistants, Mr. W. P. Flint, in 1910, with a mixture of sugar and vinegar, and another of sugar and alcohol. Altho attractive to a variety of other insects, the beetles of the locust-borer paid no attention to them. Tanglefoot, on the other hand, placed on the trees September 16, when the beetles were freely running about mating and laying their eggs, disabled the beetles and put a stop to their operations.

Highly useful directions for the management of locust plantations in a way to prevent injury by borers, are contained in Bulletin 58 of the Bureau of Entomology of the U. S. Department of Agriculture, printed in 1910.

THE OAK TWIG-PRUNER

(*Elaphidion villosum* Fabr.)

Among the more striking and curious kinds of insect injury to trees are those which take the form of amputation of twigs and small branches during the growing season—an injury which seems purposeless and excessive until one sees just how it benefits the author of it.

The oak twig-pruner (Fig. 56) is one of the best known American insects with this habit of injury, affecting, as it does, a large variety of trees and shrubs, and injuring most frequently some of the commonest and most useful species. It is best known, perhaps, for its work on oaks, hickories, and maples, altho it has been reported to attack also apple, peach, pear, plum, quince, locust, redbud, sumach, Osage orange, fir, grape, and climbing bittersweet. In Illinois we have bred it from oaks, hickories, persimmon, and peach, and have found it thruout the state. In parts of Michigan, peach-trees have sometimes been nearly destroyed by it, and an equally serious injury has been done by it in New York to pears. In Illinois we once found it at Effingham cutting off young apples-trees from one to two feet above the ground; and Dr. F. W. Goding reported it, in 1884, as doing great damage to hickory and elm at Ancona, in Livingston county. In Pennsylvania, oak forests have been so infested by it that carloads of the twigs might have been collected from under the trees; and in Connecticut, hickories have been so thoroly pruned that a barrel of twigs and branches have fallen from a single tree.

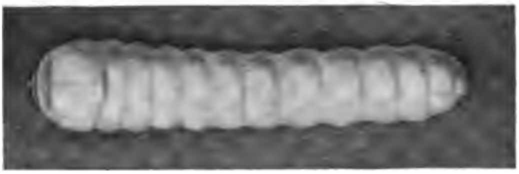

Fig. 56. Oak Twig-pruner, *Elaphidion villosum*, larva. About 5 times natural size.

The injury done by this insect is not, however, so severe as it looks. It may affect considerably the appearance of young trees, by deforming their top; but large trees are generally little harmed by the pruning they receive, and the littering of lawns with amputated twigs is at most an annoyance merely. The girdled twigs and branches may vary in length from a few inches to several feet, but Dr. Fitch mentions one that was ten feet long and over an inch thick. Commonly, however, they are a quarter of an inch or less in diameter, and vary from two to six inches in length. Occasionally a single one will contain two larvæ, the burrows then running down each side of the twig. Fallen limbs, if not disposed of, may serve, as Chittenden has said, as breeding places for various kinds of injurious borers, which may come out from them to attack and injure living trees.

The method of the pruner's work is such that a fallen twig is seen to have been hollowed out centrally—a large part of its interior often being eaten away—and plugged with sawdust, and its larger end has been gnawed off from within, having a cut surface as smooth as if made by a chisel.

The adult twig-pruner is a rather slender, dark brown beetle (Fig. 57) from a half to three-quarters of an inch in length, sparsely covered with coarse white or yellowish hairs which show a tendency to collect in irregular clumps or spots. The edge of the tip of each wing-cover is concave between two stout sharp spines or teeth, of which the outer is usually the larger. The female lays her eggs in the smaller twigs of living trees, most commonly in July. The young larva first eats out the wood under the bark in the direction of the grain, packing its burrow behind it with its castings, and working towards the base of the twig. Later it cuts holes in the bark thru which these castings are rejected, and then follows the center of the twig, making a channel more or less oval in cross-section, corresponding to its own shape. When it has reached its growth it begins to gnaw, from within, a circular groove, deepening this until the twig or branch is so weakened at this point that the wind readily breaks it off, usually carrying the insect with it. Occasionally, however, the larva is left in its burrow on the tree and finishes its transformations there. The value of this operation to the pruner would seem to be a preparation for the exit of the beetle, which originates within the burrow, but which has not jaws of a sufficient strength to enable it to gnaw its way out thru the wood inclosing it. This explanation, given by Chittenden, seems at least to be the most reasonable among several that have been proposed to account for this curious habit. After the twig has been cut off the larva within it plugs up the severed end, changes to the pupa, and later to the beetle, coming out as an adult the following summer.

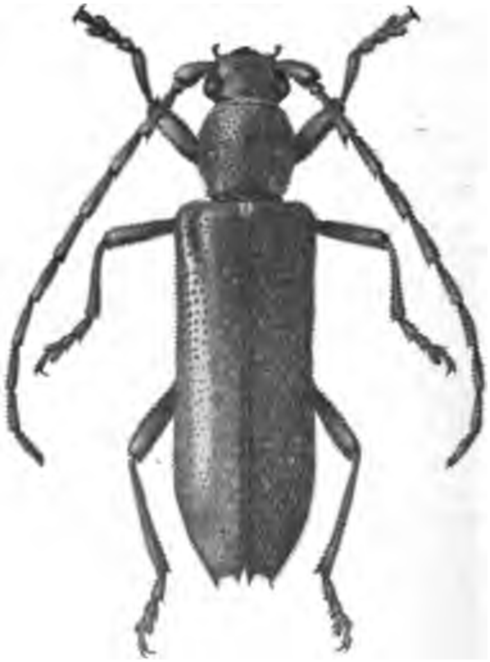

Fig. 57. Oak Twig-pruner, *Elaphidion villosum*, adult. About 5 times natural size.

Published accounts disagree as to the length of the life cycle of this species. It seems to be a single year under the most favorable conditions, but capable of being lengthened to two or even three years, particularly if the branch dies before the larva is full grown.

As nearly all the borers pass the winter in the fallen twigs, it easily follows that their injuries may be readily arrested by gathering these up and burning them in winter or in spring. This effective measure is so simple and so easily applied that no other seems necessary.

THE BRONZE BIRCH-BORER

(*Agrilus anxius* Gory)

This insect is a deadly pest of the birches, especially of the beautiful and popular white birch, which it is quite capable of exterminating locally if its presence is not early detected and if prompt measures are not then taken for its destruction. As an infested tree is not likely to last more than two or three years, the necessity of energetic measures is obvious. Unfortunately, this insect does not usually make conspicuous local marks of the injury it is doing, and the earliest sign of its presence is often the death of one or more branches in the top of the tree. If a birch is seen to be dying at the top it should at once be examined for evidences of the presence of this borer, since in some cases this condition may be due to drought or other general causes. If the bronze borer be the cause, the fact may be ascertained by lifting the bark from dead branches which are not yet dry, or from the more unhealthy looking spots on the living parts of the tree. If the insect be present, its tortuous or zigzag burrows will be noticed, and further search will disclose the borer itself in one or more of its stages of larva, pupa, or adult. Sometimes, indeed, its presence is shown by a ridged appearance of the bark, the ridges running crosswise of the branches or in a more or less spiral direction. Peculiar rusty or reddish spots may also be seen on the larger branches or on the trunk where the bark has been undermined by the interlacing burrows of the borer. Often branches weakened by the borers and by consequent decay of the wood, break at the point of injury, either hanging down or falling from the tree. This appearance is rather characteristic of the work of the borers, and may serve to distinguish an infested tree from a "stag head," due to drouth.

In its destructive stage this insect is a small, flattened, footless, creamy white grub about three-fourths of an inch long when full grown, with dark mouth-parts and a small head which is partly drawn back into the broad flat, pale brownish, first segment of the body. At the opposite end is a pair of minute forceps-like spines, brown and hornlike, with two teeth on the inner edge of each. In this larval condition the borer may be found in its burrows beneath the bark at any time during fall, winter, and early spring. If the tree has been long infested, the bark is usually perforated by small roughly semicircular holes about twice the diameter of the head of an ordinary pin. (Fig. 58.) These holes are made by the beetles when they come out in May and June for their brief life in the open air.

The beetle (Fig. 59) is a hard, small, bronze-green or violet insect, varying somewhat in size, but approximately half an inch long or a little less. It is shining but minutely punctured under a glass, with the sides nearly parallel, tapering conspicuously behind to a blunt tip, notched where the rounded ends of the wing-covers come together.

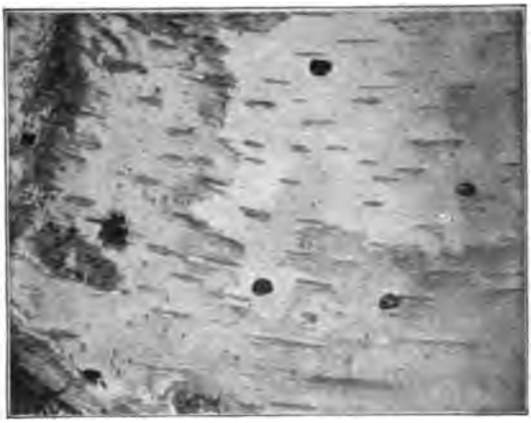

Fig. 58. Exit holes of the Bronze Birch-borer, *Agrilus anxius*, in the bark. Natural size. (Cornell Experiment Station.)

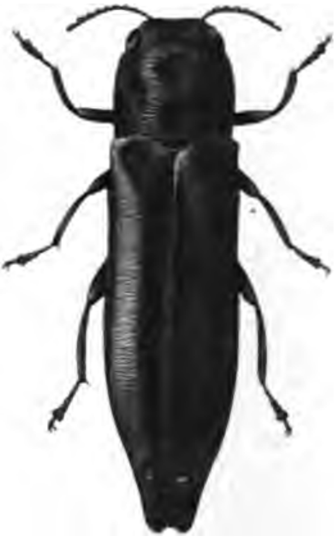

Fig 59. Bronze Birch-borer *Agrilus anxius*, adult. About 5 times natural size.

Altho most notorious for its injury to the white birch, especially the cut-leaved variety, it infests all the birches. It is the most destructive enemy of these trees in the Chicago parks, thru which it is generally distributed. It is especially dangerous because there is no means of destroying it which does not involve also the destruction of the infested tree. It is a saddening conclusion which is forced upon the owner of a beautiful birch infested by this borer, that the tree is doomed, and that the only means of saving other trees in its neighborhood is to cut it close to the ground in winter or spring, as early as the first of May, and to burn it, trunk and branches, before the beetles can emerge to lay their eggs elsewhere.

The larvæ hatch in June, and possibly also in July, from eggs laid in crevices in the rougher places of the bark. They bore thru the bark at once and begin to mine in the sapwood, sometimes dipping inward to the older wood or even penetrating to the center of a small branch. The irregular mine is always packed with the castings of the grub, and increases in diameter, of course, as the latter grows, measuring at the largest about an eighth of an inch across. Here the borer lives in the larval state until the latter part of the following April or early May, when it begins to transform within its burrow to the pupa stage, and within another month to the beetle. This escapes from the tree from the middle to the last of June in northern Illinois, by gnawing through the bark, flies abroad to feed on the leaves of trees, and soon pairs and lays its eggs. Curiously, it seems to feed but little on the birch, preferring the leaves of poplar, willow, and elm to those of its native tree. There is, indeed, some evidence that it infests the willow, producing gall-like swellings on the twigs, but the identity of the species to which this injury is referred is not positively settled.

Trees of large size are often killed by this borer within three or four years after they first become infested, and few live more than two or three years after the top branches begin to die. The necessity of prompt action is thus manifest, and as the time of the escape of the beetles varies with latitude and the weather of the year, it is best to take time by the forelock and to destroy the infested tree as early at least as April 1. Then one may be sure that nothing can have escaped from it to extend the injury.

This insect is not now known to range beyond Virginia to the south or Illinois to the west, but it very likely occurs wherever birches are grown. We have lately found it (1910) outside Chicago, in Elgin, Rock Island, Moline, and Bloomington, abundant enough in all these places to be decidedly injurious to the birches. It has been quite fully discussed by Professor M. V. Slingerland in Bulletin 234 of the Cornell University Agricultural Experiment Station, published in January, 1906, and briefer accounts may be found in the report of Dr. E. P. Felt, State Entomologist of New York, in "Insects Affecting Park and Woodland Trees" (page 284), published in 1905; in an article by F. H. Chittenden published in 1898 in Bulletin 18, new series, of the Division of Entomology, U. S. Department of Agriculture; and in a paper on "A Disease of the White Birch," by John Larsen, printed by the Michigan Academy of Science in its third report (1902).

THE SCURFY SCALE

(*Chionaspis furfura* Fitch)

The so-called scurfy scale is the commonest of all scale insects thruout the state on shade and orchard trees. The female scale

(Fig. 60, *a*, *c*) is about a tenth of an inch in length, irregularly oval, with a yellowish point at one end, and but very slightly convex. It is nearly white when fresh, but becomes gray or sooty with exposure. The scale of the male insect (Fig. 60, *b*, *d*) is narrow, with sub-parallel sides, and is marked by three longitudinal ridges. The species may be readily recognized in winter by the fact that under each female scale will be found a small mass of minute, purplish eggs. The young appear to the naked eye as active, snowy whitish or reddish specks. These insects are often so abundant on an infested tree as to give a scurfy appearance to the trunk and limbs.

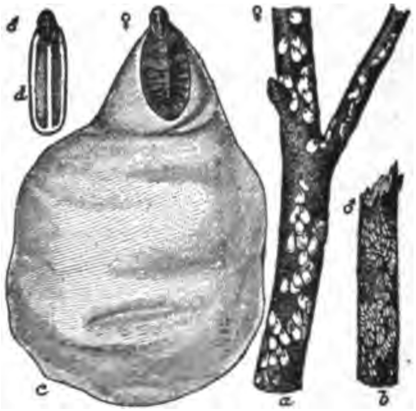

Fig. 60. Scurfy Scale, *Chionaspis furfura:* *a*, *b*. female and male scales, natural size; *c*, *d*, same, enlarged.

This scale insect is a general feeder, but is especially common on rosaceous plants. It also heavily infests the elm, which seems the most susceptible to its injuries of any of our ordinary shade trees. The red-twigged dogwood is often incrusted by it, and the mountain ash, hawthorn, pear, and currant are sometimes attacked. The scurfy scale winters in the egg, and hatches, with us, during the latter half of May—earlier or later according to the season and the part of the state. In central and southern Illinois eggs are laid for a second generation, the date of which, however, has not been accurately determined. Altho this can not be classed among the more destructive scale insects, it is nevertheless injurious where especially abundant, checking the growth and diminishing the vitality of the infested tree or shrub in a way to make it less presentable and more susceptible to the attacks of other insects and of disease.

Two insecticide sprays are fairly effective against this insect; one a winter spray of lime and sulphur, prepared and administered as described in detail under the article concerning the San Jose scale, and the other a summer spray of kerosene emulsion, a formula for the preparation of which is given under the cottony maple scale. The lime-sulphur mixture should be applied as late in the winter as practicable, best just before the opening of the leaves in spring. The kerosene emulsion must be applied immediately after the hatching process is virtually complete, a point which can only be determined accurately by careful observation. If the young are allowed to live too long they become covered and protected, after fixing themselves, by a waxy scale which the emulsion will not penetrate. It should be applied in a strength to contain ten percent of kerosene. Dr. James Fletcher, Dominion Entomologist, Canada, recommended spraying infested trees with a whitewash made by slaking a pound of lime to the gallon of water, one such application to be made in fall as soon as the leaves have fallen, and a second immediately after the first has dried. This is said to loosen the hibernating scales, which subsequently fall from the tree with the dried whitewash.

THE OYSTER-SHELL SCALE

(*Lepidosaphes ulmi* Linn.)

The oyster-shell scale is among the more conspicuous and easily recognized of the smaller scale insects of our trees and shrubs, the

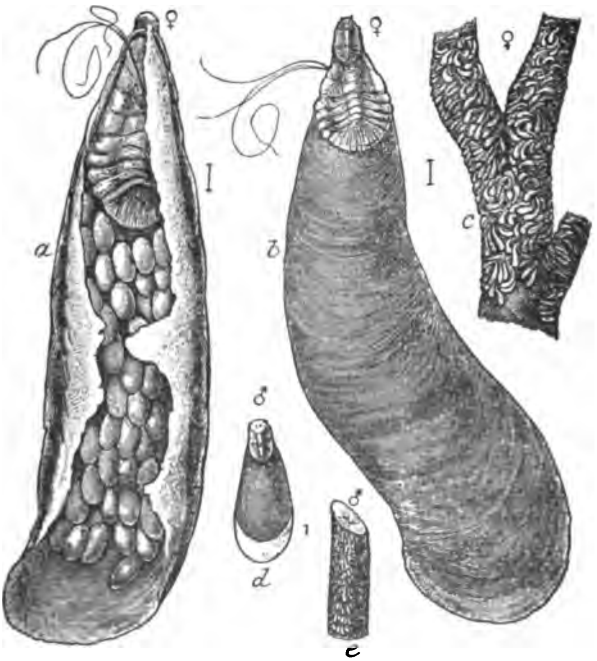

Fig. 61. Oyster-shell Scale, *Lepidosaphes ulmi*: *a*, female scale, under side, showing insect and its eggs within; *b*, same, from above; *c*, same, natural size; *d*, *e*, male scale, enlarged and natural size.

common name suggesting its most conspicuous character. It has, indeed, the convex, elongate, and more or less bent and irregular form of an oyster shell. The female scales (Fig. 61, *a, b, c*) are about an eighth of an inch long, the male scales (Fig. 61, *d, e*) smaller, with a little hinge or flap behind, thru which the winged males escape when mature. The scale is usually brown to dark brown in color, tho occasionally bleached to gray by exposure to the winter weather. The eggs of the species hatch in Illinois shortly after the time the apple blossoms fall. Each female scale has during the winter from fifty to a hundred and twenty-five pale yellowish eggs beneath it, from which the young emerge during the latter part of May or the first of June. A second generation occurs in central and southern Illinois early in July. The young are able, at first, to crawl about somewhat actively, and it is principally by this means that the species is distributed, altho it may be conveyed to distant points upon infested nursery stock. The scale insect is both larger and more injurious than the scurfy scale, and infests also a larger variety of trees and shrubs. Elm, poplar, willow, horse-chestnut, lilac, red-twigged dogwood, and currant are among those most frequently and seriously injured.

The treatment for this scale is identical with that described in the article for the scurfy scale, just preceding.

THE SAN JOSE SCALE

(*Aspidiotus perniciosus* Comst.)

This notorious and destructive pest is much less injurious to ornamental vegetation than to fruit trees and shrubs, but is nevertheless decidedly harmful to several of the former, particularly to those belonging to the family of roses. It is also very injurious to the mountain ash, but the Japanese quince (*Pyrus japonica*) is the common shrub most likely to betray its presence.

It is a circular, grayish or yellowish, scale insect about one-sixteenth of an inch in diameter, but slightly convex, and marked by a central nipple and one or two surrounding circular ridges. It is an inconspicuous object, but is recognizable by the appearance which it gives to a badly infested bark (Fig. 62), which it covers with dark gray patches of a continuous grayish crust, which exudes, when crushed with the finger-nail, an oily, yellowish substance due to the pressure on the living insects under the scales. The bark of a tree but sparsely infested may be seen, on close examination, to be irregularly specked with small circular granules which give it an unhealthy look. The surface immediately beneath the living scales often shows a reddish discoloration; and on the leaves and green twigs are more conspicuous red blotches which surround the scales.

The largest scales are about the size of the head of an ordinary pin, and the smallest ones are mere specks on the twig.

This insect passes the winter partly grown, reaches its full size in spring, and begins to bring forth its living young about the first of June, in average years, in the central part of Illinois. These may be seen as minute yellow specks wandering over the surface in search of a suitable place to establish themselves. This period of active life is often limited to a few hours, and at most to one or two days. Three or four generations are bred in a single season.

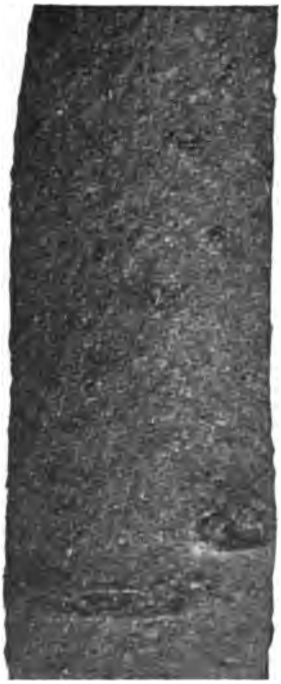

Fig. 62. San Jose Scale, *Aspidiotus perniciosus*. Natural size. (Connecticut Experiment Station.)

It has been found commonly infesting and often injuring more than seventy trees and shrubs, and occasionally nearly as many more. The commoner kinds coming under the former list are some of the dogwoods, the hawthorns (*Cratægus*), the quinces, the poplars, the cherries and pears, currants and gooseberries, roses, willows, mountain ash, snowberry, lilac, basswood, Osage orange, and the elms. Those less seriously infested are the maples, horse-chestnut, Virginia creeper, the birches, chestnut, catalpa, hackberry, the flowering and other dogwoods, the persimmon, *Forsythia,* white ash, honey-locust, *Althea,* pecan, black walnut, mountain laurel, honeysuckle, mulberry, white spruce, sour cherry, sumach, smoke-bush, locust, raspberry and the blackberry, elder, sassafras, various species of *Spiræa,* arbor-vitæ, *Viburnum,* and grape. Popular species not infested by it are *Ailanthus* or tree of heaven, papaw, spice-bush, barberry, trumpet-vine, the hornbeams, cedar, bittersweet, buttonbush, Judas-tree, fringe-tree, pepperbush, leatherwood, gingko, Kentucky coffee-tree, witch-hazel, English ivy, hickories except the pecan, hydrangeas, yellow jasmine, butternut, juniper, larches, sweet gum, tulip-tree, matrimony-vine, wax myrtle, black gum, syringa, pine, sycamore, the oaks, the rhododendrons, bald cypress, trumpet-creeper, blueberry, hemlock, *Wistaria,* and prickly ash. The last list is especially important in Illinois, thruout which the San Jose scale is certain ultimately to become generally distributed, because it includes a large and varied list of ornamentals from which selections may be made without the risk of loss or injury by this most destructive pest.

The San Jose scale is conveyed to distant points mainly by the trade in nursery stock, and otherwise it spreads only by means of the minute crawling young. Its means of dispersal are so slight that it tends to concentrate upon any tree infested until the latter becomes completely covered by it, a fact which, taken together with its numerous generations, its rapid rate of multiplication, and its freedom from parasites capable of overcoming it, make it the dangerous enemy which it has become.

The San Jose scale can be destroyed by the winter use of one of the lime and sulphur mixtures, which may either be purchased ready-made in condition for use by dilution only, or may be brought into solution by boiling the raw materials together according to the following directions.

Materials: 15 pounds of lime, 15 pounds of sulphur, and 50 gallons of fairly soft water. For 50 gallons of the spray, heat 12 gallons of water in a 40-gallon iron kettle, mixing, in the meantime, in a separate vessel, 15 pounds of sulphur with enough water to form a thin paste. Add this sulphur to the water in the kettle and bring the mixture to a temperature just below boiling. Then add 15 pounds of best lump lime, keeping cold water at hand to use as the mixture threatens to boil over. After the lime is fully slaked, boil for 40 minutes, with almost constant stirring. Then strain into a 50-gallon spray-tank and fill with water, which had better be warm, although cold water will do. To prepare 100 gallons of the spray at a time, heat 20 gallons of water in the 40-gallon kettle, add 30 pounds of sulphur—previously reduced to a thin paste with water—and to this put 30 pounds of lime. Boil as before, and dilute to 100 gallons.

If a supply of steam is available for cooking the mixture, this will be found a much more convenient source of heat. The cooking is then done in barrels or other vessels, from which the fluid is strained into the spray-tank. The disturbance caused by the introduction of steam makes stirring unnecessary. When cooked with steam the mixture does not ordinarily become so dark as when boiled over a fire, but the insecticide effect is nevertheless the same.

PUTNAM'S SCALE
(*Aspidiotus ancylus* Putnam)

This is a circular or oval, dark gray or black, scale insect, about one-twelfth of an inch in diameter, with a brick-red point at one side of the center. It closely resembles the San Jose scale in general appearance, but does not present the conspicuous ring and nipple structure of the latter, altho the young have usually a nipple and a rather indefinite ring.

It passes the winter but partly grown, but differs from the San Jose scale in the fact that it reproduces by means of eggs laid in late spring or early summer. There is but one generation in a season.

It has been found on elm, willow, oak, hemlock, mountain ash, *Ilex,* white birch, *Prunus,* ash, beech, hackberry, linden, maple, Osage orange, and water-locust. It is rarely injurious enough to require special attention.

THE WALNUT OR WILLOW SCALE
(*Aspidiotus juglans-regiæ* Comst.)

This species, altho common on a number of shrubs and shade trees, is of little importance except on the willow, to which it is a veritable pest. It is easily distinguished from other scales of the San Jose relationship by its relatively large size, its diameter being 3 mm., or an eighth of an inch. The female scale (Fig. 63, *a, e,*) is circular, flat, with a prominent pink or reddish point at one side of the center. The male scale (Fig. 63, *b, d*) is elongated, with a corresponding point near one end. The female passes the winter as an adult, and lays her eggs in early spring.

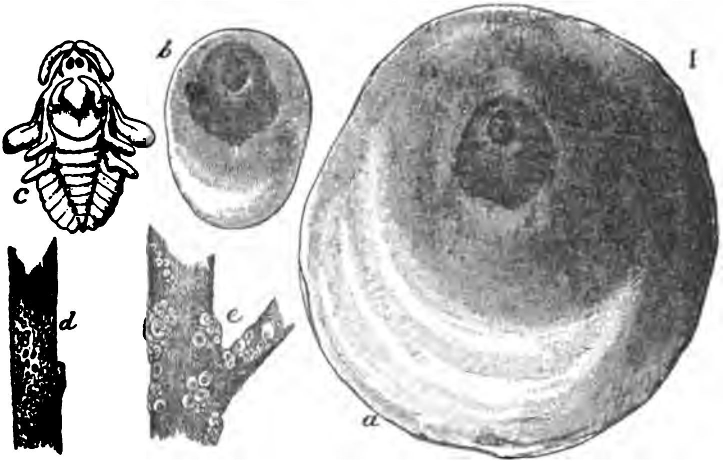

Fig. 63. Walnut Scale, *Asp'diotus juglans-regiæ: a, b* female and male scales, enlarged; *c,* male pupa; *d, e,* male and female scales, natural size.

Treatment the same as that for the scurfy scale.

THE COTTONY MAPLE SCALE

(*Pulvinaria vitis* Linn.)

The cottony maple scale (Fig. 64) is one of the best known scale insects because it heavily infests several very common shade trees, and because the cottony masses beneath the body of the adult female in early summer make it a very conspicuous object. These large white masses are a deposit of waxy threads within which are the minute, oval, pale yellowish eggs.

The history of this insect in Illinois since 1867 exhibits successive periods of abundance and of scarcity, each averaging about four or five years for the state as a whole. That is, thruout some considerable part of the state, and often over most of it, the maple scale has been injuriously abundant once in eight or ten years, and its period of abundance has lasted, as a rule, about half this time. In any given locality, however, it has usually been injurious for a much shorter time, often for not more than one or two years. The cessation of its injuries and its virtual disappearance from the trees infested by it have seemingly been due almost wholly to the agency of its insect enemies.

The soft maple (*Acer saccharinum*) is the tree most generally and heavily infested by this insect. The hard maples, on the other hand, are infested but slightly if at all. The box-elder is also greatly subject to injury, and next to this, perhaps, the linden or basswood. Among the other trees and woody plants often more or less injured, are the elm, honey-locust, black locust, black walnut, sumac, willow, poplar, beech, hawthorn, bittersweet, grape-vine, and Virginia creeper. We have found mature egg-laying females on the horse-chestnut, honeysuckle, dogwood, trumpet-creeper, mulberry, snowberry, smoke-tree, *Spiræa,* false syringa (*Philadelphus*), and *Wistaria.* Oak, ash, and catalpa are not infested in northern Illinois, but injury to oaks is reported from Georgia. The pear is said to be most liable to injury among the fruit trees, and apple, plum, and peach are sometimes infested. Serious damage to fruit trees is, however, very unlikely. The migrating young, which are often washed from trees by rain, or blown off in considerable numbers, may maintain themselves for a time on a great variety of woody and herbaceous plants, those on the latter, of course, perishing with the advent of frosts.

In early summer this scale, when very abundant, coats the under side of heavily infested limbs with a thick layer of cotton-like waxy masses, each projecting from beneath a brown cap or scale—the flat body of the mature female. This "cotton" is secreted and the eggs are deposited within it in late May or early June in the latitude of central Illinois, but usually one or two weeks later in the Chicago district.

Something over 3,000 eggs are usually laid by each female, the number ranging, in our counts, from 2,856 to 3,863, with an average

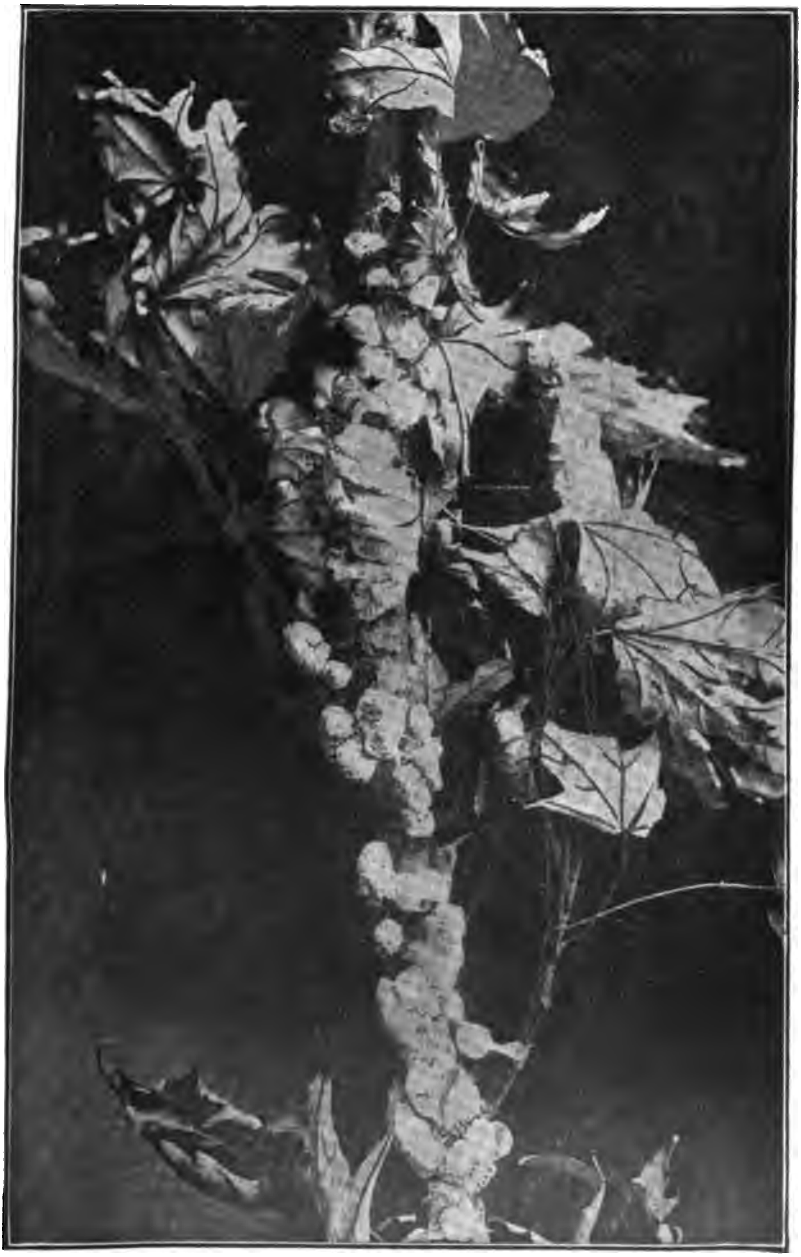

Fig. 64. A Soft maple twig badly infested with adults of the Cottony Maple Scale, *Pulvinaria vitis*. About natural size.

of 3,410. In central Illinois the eggs ordinarily hatch in June, and in the northeastern part of the state in early July, or later if the weather of the time is unfavorable. Virtually all are hatched, as a rule, by the end of July.

When first hatched the six-legged young (Fig. 65, *a, e, f*) move slowly about as creeping yellowish specks about twice as long as wide. They soon settle upon the leaves, mostly upon the under side along the veins, but a considerable percentage also on the upper surface. Soon after settling down, a thin waxy layer forms on the back, and in about three weeks the insect has virtually doubled in size. As they increase in size the male and female scales become distinguishable (Fig. 65, *b, c, d*) by the fact that the former are comparatively narrow and more convex. From these the winged males (Fig. 66, *a, b, c*) emerge to fertilize the stationary females in August and September, perishing soon thereafter. In autumn the young females migrate from the leaves, which are about to fall, to the twigs, upon which they pass the winter and, indeed, the remainder of their lives. In spring the female scale (Fig. 67) is elliptical, convex on the back, with a low, rounded, median ridge. It is pale greenish or whitish yellow, marked with black or dark brown. When full grown, about the middle of May, it is 4 to 6 mm. long and 3 to 4.5 mm. wide. Its body is at first closely applied to the surface of the twig, but with the development of the eggs beneath it the abdomen is gradually raised from the bark to an angle of forty-five degrees or more.

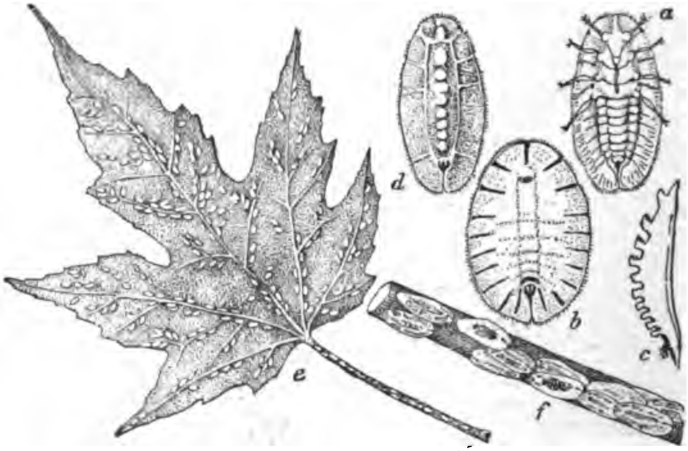

Fig. 65. Cottony Maple Scale, *Pulvinaria vitis*, immature stages: *a*, newly hatched young, under side; *b, c*, young female, top and side views; *d*, young male; *e, f*, young on leaf and leaf stem. Natural size shown in *a*.

It is usually difficult to say whether trees infested by this insect should receive special treatment, or whether they may be safely left to the natural course of events. The cottony maple scale is extremely subject to parasites and attacks of other insect enemies, particularly to the black hemispherical ladybugs and their larvæ, the latter of which feed upon the egg masses in spring and summer. With an extraordinary abundance of the scale insects themselves these insect enemies improve the opportunity for unusual multiplication in a way to produce a greater number than can possibly be maintained permanently by the scale insects. A check is thus put upon the increase of the latter which, within a few months, may reduce them to insignificance. The consequence is an irregular periodicity in the numbers of the cottony maple scale such that two years of injurious abundance rarely succeed each other in the same place. Nevertheless, where trees are evidently suffering from the scale attack it is always prudent, and often necessary, to take artificial measures of protection.

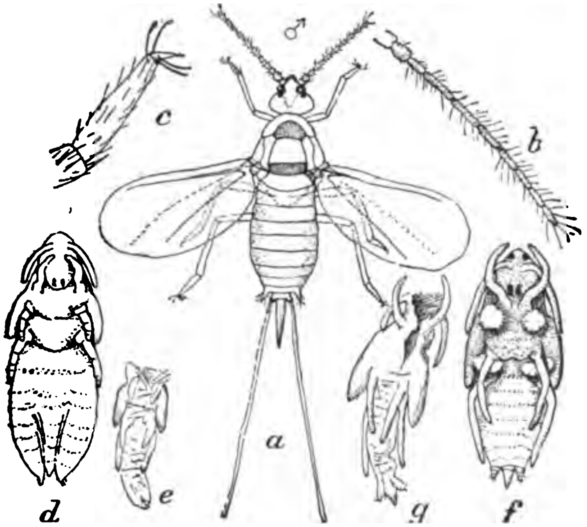

Fig. 66. Male of Cottony Maple Scale, *Pulvinaria vitis:* *a*, adult; *b*, *c*, antenna and leg enlarged; *d*, *e*, second stage of pupa and its cast skin; *f*, *g*, true pupa and its cast skin. All greatly enlarged.

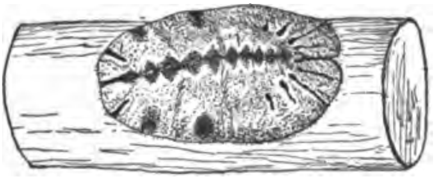

Fig. 67. Cottony Maple Scale, *Pulvinaria vitis*. Adult female in spring, just before the formation of the cottony egg sac. Enlarged.

As the newly hatched young are especially susceptible to the petroleum insecticides, which act by contact, a definite knowledge of the hatching period has an important practical value. In central Illinois this period extends approximately from June 15 to July 20. In and about Chicago it commonly begins about two weeks later, and continues for a period of three weeks, this retardation being apparently due to the higher latitude and to the neighborhood of Lake Michigan. The period varies, in short, as to its beginning time, with the advancement of the season, and once begun, the rapidity of the hatching will depend, other things being equal, on the warmth of the weather. It is also influenced locally by the amount of foliage on the trees, the eggs hatching later and more slowly in a dense treetop than in one more open to the sun.

The only insecticides available against these insects are those which kill by contact, and of these the kerosene mixtures have thus far been found the most useful. Even these can be applied only to the young scales shortly after they hatch from the egg, no insecticide treatment being available for the destruction of the large and conspicuous females upon the twigs in May and June. The common kerosene emulsion, made by thoroly and intimately mixing kerosene with one-third of its volume of a strong soapsuds, is a satisfactory spray when diluted to contain ten percent of kerosene for summer use, and sixteen to eighteen percent is used in winter. As a summer spray this emulsion must be used twice in succession, once when about half the eggs are hatched and again about ten days thereafter. A single treatment in winter is about the equivalent in practical effect of two such summer sprays. Large trees in a sandy soil, and especially those in more or less unthrifty condition, should be guarded against possible injury to the roots from the dripping of the kerosene spray, or from that part of it which may run down the trunk and so reach the earth. For this purpose it would be well to cover the ground before spraying with a thin layer of straw, packed closely around the base of the trunk, and later to gather this up and carry it away.

The cost of materials for large trees will average approximately fifteen cents a gallon for the summer spray, and about twice as much for the winter strength.

Kerosene emulsion is made as follows: Dissolve one pound of common soap, or half a pound of whale-oil soap, in one gallon of water by boiling, remove from the fire, and add two gallons of kerosene. Then with a spray pump force the mixture back into itself for about five minutes, or until it presents the appearance of a thick cream and no longer separates on standing. This is the undiluted emulsion. For a mixture containing ten percent of kerosene, add seventeen gallons of water to the three gallons thus prepared. For an eighteen-percent kerosene emulsion, add eight gallons of water to the stock emulsion. Soft water is to be preferred.

The following tables will show the effects of kerosene sprays as applied by us in 1905 and 1906.

SUMMER SPRAY

Treatment		No. of trees	Leaves examined	Scales examined	Percent killed by spray
Insecticide	Part of hatching period				
10 percent kerosene	Beginning	1	75	48,789	33
10 percent kerosene	Middle	1	50	19,425	64
10 percent kerosene	End	3	150	281,271	68
10 percent kerosene....	Middle and end	1	100	57,179	82

WINTER SPRAY

When sprayed	Percent of kerosene	Date of counting	Scales counted	Percent killed
December 26 to January 5 (once)..............................	19	Feb. 1	12,703	86
January 11 to 13 (once)......	20	Feb. 1-2	23,061	91
January 11 to 13 and March 30 (twice)............	19-24	June 10	48,395	91

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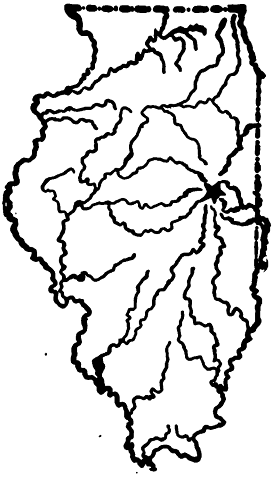
UNIVERSITY OF ILLINOIS
Agricultural Experiment Station

BULLETIN NO. 152

CONTAGIOUS ABORTION OF COWS

By W. J. MacNEAL in Coöperation with HERBERT W. MUMFORD



URBANA, ILLINOIS, NOVEMBER, 1911

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SUMMARY OF BULLETIN NO. 152

1. The existence of a specific contagious disease causing abortion in cows has been recognized for a long time, and it is certain that the disease known abroad as infectious or contagious abortion is also prevalent in the United States.

2. The infectious agent is a bacterium first described by the Danish investigators, Bang and Stribolt. This microörganism has been isolated from aborting cows in various European countries and in the United States.

3. Bacteriological examination of afterbirths from aborting cows at this Station revealed the presence of this germ.

4. To eradicate the disease from a herd, the affected cows should be isolated, and their genital passages cleansed once or twice daily with an antiseptic solution until all discharge has ceased, when they may be returned to the herd; all infectious material (afterbirth and discharges) should be burned; infected stalls should be cleaned and disinfected; the sheath of the herd bull should be cleansed with a disinfectant solution before and after service, and a separate, clean bull should be used for heifers and clean cows.

CONTAGIOUS ABORTION OF COWS

BY W. J. MACNEAL, ASSISTANT CHIEF IN BACTERIOLOGY, IN CoÖPERATION WITH HERBERT W. MUMFORD, CHIEF IN ANIMAL HUSBANDRY

INTRODUCTION

The premature discharge of the products of conception from the uterus is a not infrequent occurrence among domestic animals, and doubtless various factors may from time to time operate in its causation. For a long time, however, practical husbandmen have recognized an epizoötic or contagious kind of abortion, a definite transmissible disease in which the loss of the fetus is the most prominent characteristic. The transmissibility of contagious abortion of cows appears to have been demonstrated experimentally for the first time by Brauer. Experimental transmission has been performed by a number of investigators subsequently, the work of Nocard (1886) furnishing conclusive evidence upon this point.

It is certain that a disease, or possibly more than one disease, of this nature is a source of serious loss to the live stock industry in the United States, and there can no longer be any doubt that a considerable part of this loss is due to the definite specific disease prevalent on the continent of Europe and in England, and known as Contagious, Infectious, or Epizoötic Abortion. The purpose of this bulletin is the brief presentation of some of the facts concerning the cause, prevention and restriction of this disease, which have been established by modern investigation, for the information of men engaged in live stock production.

BACTERIOLOGICAL INVESTIGATIONS ELSEWHERE

Nocard carried out the first extensive bacteriological investigation of contagious abortion. In microscopic preparations of the diseased placenta he was able to recognize numerous short bacilli and micrococci. These were also found in the amniotic fluid. He obtained pure cultures of these two organisms, but failed to induce abortion upon inoculating these cultures into other animals. Neither of the germs obtained in culture could therefore be regarded as the causative agent in the disease.

In 1895 Bang and Stribolt undertook the investigation of this disease, and their results are now generally regarded as the most important of all the contributions to the study of this subject. A cow showing all the symptoms of impending abortion was purchased and slaughtered. The unopened uterus was removed to the laboratory where it was opened with special precautions to avoid all contamination. An abundant, grayish yellow, odorless exudate was found between the ovum and the inner wall of the uterus. Upon standing this exudate separated into two layers, a reddish yellow serum above, and a grayish yellow partly solid layer below. In microscopic preparations of this exudate, stained with Loeffler's methylene blue, numerous very small bacilli were found, apparently in pure culture, some of them lying free, but large numbers of them crowded together inside cells. These latter appeared at first to be micrococci, but more careful examination proved them to be really short rods. Bang and Stribolt were able to cultivate this organism in tubes of a gelatin-agar-serum medium, the germ developing only in a particular zone beginning about 5 mm. beneath the surface of the medium and extending downward 10 to 15 mm. After considerable work with cultures, they concluded that the bacillus is neither an aerobe nor an anaerobe, in the ordinary sense, but exhibits a very peculiar behavior in respect to oxygen, requiring for its development a partial pressure of oxygen somewhat less than that present in the atmosphere. They were unable to obtain growth of the germ in the presence of the ordinary atmosphere, nor in the absence of oxygen (Pyrogallol method). Curiously enough, by placing their tube cultures in an atmosphere of pure oxygen, they obtained cultures developing in two zones, one near the top and the other near the bottom of the tube, indicating that there are two optima in the oxygen requirement of the organism. This very interesting character of the organism received great attention at their hands, but nevertheless Bang points out that typical development such as he has pictured was not always obtained, a number of factors seeming to cause variation in the position and extent of the developmental zones in these tube cultures. By exhausting the air above the medium in the tube, the growth was made to extend to the surface. In this way they were able to obtain growth of the bacillus on plates, but they did not work out a reliable plate method, preferring to employ the dilution tube cultures for separation in all their work. Bang and Stribolt subsequently examined pieces of placenta from a large number of cases of contagious abortion, and found the bacillus microscopically in practically all cases. Sometimes they were abundant, in other instances very scarce. Most of this material was badly contaminated, yet, from that sent in during the colder season they successfully isolated the bacillus in pure culture in a majority of the cases. In three fetuses the bacillus was found in the intestinal contents in pure culture; in one fetus it was isolated from the blood. Two cows with mummified fetus *in utero* were examined *post mortem*. These fetuses had been dead 9 months and 5 months respectively but the surrounding exudate still contained the abortion bacillus and pure cultures of it were obtained from each case. Uterine exudate kept in the refrigerator still contained living abortion bacilli after seven months.

Having found the same bacillus microscopically in a series of cases of abortion, and having obtained it in pure culture from a number of them, it now remained for Bang and Stribolt to produce the disease by inoculation of these cultures into healthy animals. Four pregnant cows were obtained without knowledge of their previous history. Two of them were inoculated by intravaginal application of pure cultures, and two by intravaginal application of pieces of afterbirth from aborting cows. No abortion resulted in any of the cows and at slaughter 19 to 29 days after inoculation, there was no evidence of the disease. This result was surprising, as Brauer had induced abortion by the second of the above-mentioned procedures in from 9 to 21 days, Lehnert in from 12 to 20 days, and Trinchera in 9 to 13 days. The authors thought that the animals may have been immune on account of a previous attack of the disease, or that possibly the interval between innoculation and slaughter (19 to 29 days) may have been too brief for the disease to have developed. For the next experiment two cows were purchased from a region where abortion was unknown. Pregnancy began January 14 and January 16, 1896. On April 14, a rich culture of the abortion bacillus was injected well up into the anterior end of the vaginal canal of each of these cows. The inoculation was repeated in the same way on May 23, and again on June 4. One cow aborted June 24, the fetus evidently having been dead some days. The abortion bacillus was isolated from the afterbirth. The other cow showed the signs of impending abortion on June 23, and was slaughtered on June 24. The condition inside the uterus resembled in every respect that observed in the cow from which the original culture had been isolated, and the bacillus was present in pure culture. In these cows the disease had appeared 10 weeks after the first inoculation. A third cow was inoculated by intravaginal application January 19, 1897, and subcutaneously March 6, in both instances with pure cultures of the bacillus. Premature delivery of a living calf occurred April 9, 80 days after the first inoculation. Abortion was also caused in sheep by intravaginal application and by intravenous injection of pure cultures. Inoculation by the latter method proved to be more certain in these animals, and the incubation period after intravenous injection was only 7 days in one case and 12 days in another. Intravenous inoculation of a mare resulted in a premature delivery after 28 days. In all these cases the bacillus was recovered from the afterbirth.

In 1902, Preisz at Budapest isolated the same bacillus from two cases of contagious abortion in cows. He confirmed the findings of Bang in respect to the oxygen requirements of the organism, and was able to obtain cultures by a variety of methods on ordinary media. Apparently his cultures were less vigorous than those of Bang, for they soon died out, their resistance to germicides was slight, and all his inoculations into animals, including two pregnant cows, two pregnant guinea pigs, and one pregnant rabbit, as well as a number of other small animals, were without positive result. Preisz named the organism *"Corynebacterium abortus endemici (s. infectiosi)."*

In 1908, Nowak at the University of Krakau in Austria made a very important contribution to the study of this disease. He found the culture method of Bang and Stribolt very useful for the identification of the organism when obtainable in pure culture, and when the contaminating bacteria were few in number. When other bacteria were numerous, as is frequently the case in material obtained for examination, he found this method difficult. The pyrogallol method of Preisz also proved to be unreliable in his hands. Eventually he devised a method of plate culture which proved to be very useful. Ordinary agar was melted and cooled to 50° C. then mixed with about one fourth its volume of naturally sterile blood serum, and poured into sterile Petri dishes where it was allowed to solidify. The piece of placenta or other material to be examined was then streaked over several of these plates in succession, and the plates were incubated for 24 hours at 37° C., to allow contaminating bacteria to develop. The plates were next placed in a glass jar together with a culture of *Bacillus subtilis,* one square centimeter of culture surface of the latter organism being provided for each 15 cc. capacity of the jar. The jar was sealed and placed at 37° C. for three days, at the end of which time excellent surface colonies of Bang's bacillus were obtained. By the application of this method Nowak has succeeded in isolating the bacillus from the blood and intestinal contents of a number of fetuses, and from uterine discharge, when other methods failed. He has also observed that one could gradually decrease the amount of culture surface of *B. subtilis* employed in succeeding cultures and eventually get the bacillus of Bang to grow in the presence of atmospheric air, altho the cultures were relatively poor ones. Nowak also confirmed Bang by obtaining cultures in an atmosphere of nearly pure oxygen, as well as in ordinary air under a pressure of three atmospheres. His cultures were evidently vigorous for some of them were successfully transplanted after two years. Nowak used ordinary agar as a medium with considerable success, and found glucose agar to be almost as favorable to the growth of the bacillus. For the detection of the germ in pathological material, however, these media proved to be inferior to the serum-agar mixture in several cases. Cultures were obtained in broth and in milk without coagulation, contrary to the statement of Preisz. No gas was produced in sugar broth. Nowak inoculated a number of pregnant laboratory animals, and produced abortion with great regularity in guinea pigs and rabbits by subcutaneous, intravenous and intraperitoneal injection. He did not succeed in producing abortion by intravaginal application nor by feeding. No tests were made upon larger animals much to his regret, as in his opinion the experiments of Bang upon cows still left something to be desired in the way of experimental evidence.

McFadyean and Stockman (1909) have investigated the contagious abortion of cattle in Great Britain, and have found it to be identical with that studied by Bang in Denmark. They were able to produce the disease in cows by intravenous injection of natural virus and of active pure cultures, without a failure in eight experiments. By intravaginal application they caused the disease twice with cultures and three times with natural virus, but also failed to obtain any result in three trials with the natural virus. Subcutaneous inoculation was successful three times in five trials. By feeding they produced the disease three times in four trials. These authors consider ingestion to be an important mode of contracting contagious abortion in nature.

Zwick (1910) has made a preliminary report of the bacteriological investigation of contagious abortion at the German Imperial Health Office. By a comparative study of cultures, the unity of the disease in Denmark, Germany, England, and Holland has been established. Certain individual differences were detected in the various culture strains examined, and it was found that the bacillus could be readily cultivated upon various ordinary laboratory media, and that it could also adapt itself to an aerobic existence, thus confirming the work of Nowak. In one instance the bacillus grew aerobically immediately upon isolation from the animal body. Abortion was induced in sheep, goats, and rabbits by intravenous injection, intravaginal application, and also by feeding. Work upon the use of abortin (analogous to tuberculin) for diagnosis, and upon the agglutination and complement fixation tests, was in progress at the time the report was made.

BACTERIOLOGICAL OBSERVATIONS AND EXPERIMENTS AT THIS STATION

In the United States contagious abortion is widespread, and has been recognized for a number of years by practical husbandmen as an important economic factor in animal industry. Epidemiological studies have recently been reported from Arizona and Connecticut. At the Illinois Agricultural Experiment Station the beef cattle herd has suffered considerable loss from abortion for several years past, and the presence of contagious abortion had been recognized by Professor Mumford, altho this diagnosis was disputed by other authorities. In order to settle the question it seemed best to undertake a bacteriological study of the disease. This seemed the more desirable because, so far as we have ascertained, there was no known microörganism generally recognized and accepted as the cause of the disease in this country, the bacillus described by Bang having been found only in Europe and his work having failed to be confirmed by American investigators.

Altogether eighteen parturient cows have been examined bacteriologically. Ten of these calved at term and the births appeared to be normal. The abortion bacillus was not found in any of these. Eight were cases of premature delivery, and of these, six appeared clinically to be cases of contagious abortion. Placental tissue from two of these cases was examined by the Nowak plate method and a bacillus isolated, apparently identical with that isolated by Bang in Denmark and by Nowak in Austria.

The organism is a very small short rod, usually oval in shape, from 0.8μ to 2.0μ long by 0.7μ wide, practically always single, rarely in short threads of two to four cells. It is not motile, and does not form spores. It stains with moderate rapidity with the ordinary anilin dyes, and is decolorized by Gram's method. The colonies on serum-agar are raised, with smooth circular borders, appearing almost like drops of dew. They are transparent and very clear, with a bluish gray color by transmitted light. Under the microscope a few coarse granules may be seen near the center of the colony but the greater part of it appears very homogenous and almost water-clear. The appearance of the colony is really a very characteristic feature of the organism and enables one to distinguish readily the colony of the abortion bacillus from other colonies on the serum-agar plates.

The behavior toward oxygen is another character upon which considerable reliance may be placed in the identification of strains recently isolated from the animal body. This is tested by transplanting the colonies from the serum-agar plates to two series of agar streak sub-cultures, of which one series is incubated in the atmospheric air and the other in the closed jar together with cultures of *B. subtilis.* Unless the growth under the latter condition is much better than the growth outside the jar, the culture may be discarded as one not belonging to this species.

A final important test in identification is that of pathogenicity. Nowak induced abortion in pregnant guinea pigs with great regularity by subcutaneous, intraperitoneal, and intravenous injection of pure cultures of the abortion bacillus. So far, four pregnant guinea pigs have been inoculated subcutaneously with the pure cultures isolated by us, and the inoculation has been followed by premature evacuation of the uterus with death of the fetuses in 3½, 8, 6, and 7 days respectively. In the first guinea pig the two fetuses were practically fully developed and covered with hair. In this instance the abortion bacillus was isolated only from the subcutaneous tissue of the mother at the point of inoculation, the cultures from the uterus, the placenta, and the fetuses remaining negative. In the other three cases the fetuses were undeveloped and the condition was that of a true abortion. In these instances the abortion bacillus was demonstrated by culture tests at the point of inoculation in pure culture in two, in mixed culture in the other one; in the interior of the uterus in pure culture in all three; in each of the four placentæ of two cases in mixed culture, as these placentæ had been passed some time before they were found, and in the three placentæ of the other case in pure culture; in the livers of all three fetuses of the one case in pure culture, but not in the other four fetuses; in the heart blood of the mother in pure culture in one case, but not in the other two cases. In all these tests the mother guinea pig was killed by chloroform soon after the abortion had occurred.

From the results of these tests we have concluded that the bacillus isolated by us from aborting cows is identical with that isolated by Bang and by Nowak. Further, the investigations of Bang, Preisz, Nowak, McFadyean and Stockman, and Zwick, seem to justify the acceptance of this organism as the infectious agent in the contagious abortion of cattle.

The principles of bacteriological nomenclature have not as yet been universally adopted, and most of the investigators quoted in this paper have avoided the use of a specific name for the abortion bacillus. Bang himself seems not to have given it a binomial designation, but he repeatedly employed the term "Abortusbacillus" as a specific term. Chester (1901) has named the organism "*Bacterium abortivum*" with the synonym "Bacillus of contagious abortion in cows, Bang." Preisz (1902) suggested the name "*Corynebacterium abortus endemici (s. infectiousi).*" This generic name Corynebacterium appears to be incorrect, as the organism is very different from those to which this name has been previously applied. It would seem best to employ the more general term Bacillus (or Bacterium) as a confessedly temporary generic name until a more definite generic nomenclature of bacteria shall have been developed and generally adopted. In determining the specific name it would seem that the term "Abortusbacillus" employed by its discoverer as early as 1907 should receive first consideration. We* have therefore suggested the name *Bacillus* (or *Bacterium*) *abortus*, Bang, for this organism. The term "*abortus*," being in the genitive case, may be employed with either generic term.

RESTRICTION AND ERADICATION OF THE DISEASE

Reliable methods for restricting the spread of contagious abortion and for eradicating it from a herd may be expected as the

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***MacNeal and Kerr, 1910.**

result of more complete and accurate knowledge of the nature of the disease and its mode of spread. Some of these methods, such as that of artificial immunization, are being tested experimentally by the Departmental Committee appointed by the British Board of Agriculture and Fisheries to inquire into Epizoötic Abortion. Until these methods have been developed beyond the experimental stage, the older more or less empirical methods will have to be relied upon. Fortunately these older methods can now be subjected to careful scrutiny in the light of modern knowledge of the disease, and they have been studied in this way by the British Committee mentioned above. The following summary has been copied, with only slight abridgment and very few alterations, from the report of this Committee.

"The methods which have been relied upon in the past for the prevention of abortion and its eradication from a herd are:—

(1) Periodical spraying of the external genital organs and hind quarters with disinfectant solutions.

(2) Isolation of animals as soon as they show the premonitory signs of abortion.

(3) Internal administration of carbolic acid to animals supposed to be infected or exposed to infection.

(4) Irrigation of the genital organs of animals which have aborted with antiseptic solutions.

(5) Removal and disposal of animals which have aborted.

(6) The keeping of a special bull for serving animals which have aborted, or, what is based on the same idea, the disinfection of the external genital organs of the bull with antiseptic solutions after he has served such a cow.

(7) Destruction of the abortion membranes, and disinfection of the parts of the buildings, litter, etc., with which the infective material has come in contact.

(8) The keeping of a goat, especially a male goat, in a byre with the cows.

It cannot be said of the above measures that either singly or collectively they have brought about any material improvement in the general condition of our herds in relation to abortion. According to reports, decided improvements have been effected in individual herds by the adoption of isolation and disinfection, while in others very little has been accomplished. Some of the above methods are founded on nothing more than ignorant empiricism, while others are based upon pathological and physiological considerations which are only partially correct in their applications. Since most of them have obtained a certain amount of hold, at least on the minds of stockowners, it may be useful to discuss each measure separately in the light of our recent investigations.

Spraying of the External Genital Organs.—This is a procedure which probably has little or no value. (*Abridged.*)

Isolation of Animals as soon as they show Signs of Abortion.—The necessity for this measure is obvious, and its importance cannot be too much insisted on. An infected animal only becomes infective to others immediately before the act of abortion, and may remain so for some weeks afterwards. However, only a proportion of the affected animals show premonitory signs, and quite a number may abort amongst their companions without warning. Under such conditions, then, measures of immediate isolation lose much of their undoubted theoretical value, owing to the difficulty in the way of carrying them out in practice. There is not likely to be any serious difficulty in diagnosing the bacterial disease after an act of abortion, even in an isolated case, if the membranes are available in a reasonably fresh state. (*Abridged.*)

Isolation of the affected animals, however, must be complete before and after the act to be of any real value. Having regard to what appears to be the most common form of infection, viz., by ingestion, we do not think that anything material is to be gained by merely putting all the cows about to abort and those which have aborted at the lower end of a byre, so that the infective discharges may not come in contact with the external genital organs of their fellows, unless we assume that infection frequently takes place by an animal licking virulent material from a part of its body where it has been deposited by flicks of the tail which has been contaminated by lying in the gutter behind the stalls.

Internal Administration of Carbolic Acid.—The uselessness of carbolic acid and other antiseptics as curative agents has already been referred to. As a preventive agent by internal administration we believe carbolic acid to be equally useless. Even if it were possible to administer very large doses of this poisonous substance, one could not expect to be able to give enough to destroy the bacilli which have been swallowed and mixed with the contents of the enormous stomachs and intestines, and it would be equally hopeless to expect to destroy in this way the bacilli which have already reached the womb. This alleged measure of prevention must be regarded as an absurdity which has gained a certain amount of support owing to observations carelessly collated and carelessly interpreted.

Irrigation of the Genital Passages after Abortion.—With the act of abortion the greater part of the uterine exudate is immediately ejected. That some of it remains behind for a short period is certain, since we were able to demonstrate abortion bacilli in material obtained from the vagina of a heifer three days after she had aborted. On the other hand, no abortion bacilli could be found in the uterus of another heifer a month after she had aborted. It seems probable that, as a rule, the genital organs cleanse themselves by natural means a comparatively short time after abortion has taken place. Almost immediately after abortion and expulsion of the membranes the uterus contracts, and its internal surfaces come into apposition. Its condition is such that it would not be possible to force fluid into it with a pump from the vagina. Apart then, from the probability that disinfection of the uterus by antiseptics is not necessary to rid the organ of abortion bacilli, we are of opinion that it is futile to attempt it by irrigation methods. So long as a discharge continues to come from the genital passages, we think that for hygienic and therapeutic reasons they ought to be cleansed once or twice by the intravaginal injection of tepid antiseptic solutions, such as a 2 per cent solution of carbolic acid or a 1 in 3,000 solution of corrosive sublimate, but not on the ground that the injections will disinfect the uterus. We are of opinion that it will seldom be necessary to continue the injections for more than a month, and that after three months there should be small risk in putting the cow to the bull, provided she is afterwards protected from fresh infection.

Removal and disposal of Animals which have aborted.—It is quite a prevalent custom to feed for the butcher cows which have aborted. It is also customary to sell such cows alive in the open market. The second custom we consider likely to introduce disease to other establishments, unless the animals have ceased to discharge; they should, we think, be kept for at least three months after abortion before being sent for sale.

The first custom is less objectionable than the second, but we think that a breeder will be more likely to get rid of abortion from his herds by keeping such animals than by disposing of them and bringing in new ones before his entire herd is free from the disease. There can be no doubt that in most cases an attack of the disease greatly increases an animal's resistance to future attacks, and that in a large proportion of the affected, probably in the majority, this resistance is sufficient to fortify them against infection during their next pregnancy. It is beyond doubt that a considerable proportion may abort twice in succession, but it is not improbable that inoculation methods may now be successfully employed to exalt their resistance. In the midst of infection there is no better guarantee against the disease than the possession of an immune stock, and for this reason we consider that on infected premises the animals which have already aborted are to be looked upon as valuable assets for purposes of eradication, much more valuable than the new and susceptible animals brought in. We find, however, that a small proportion of cows will not hold to the bull for an indefinite period after abortion, and it may be found better to fatten off such animals, unless they are of high value.

The Keeping of a Special Bull for Cows which have aborted.—We have already stated that we do not consider the bull a factor of the first importance in the dissemination of abortion but that infection by means of a contaminated bull must be looked upon as a distinct possibility. We think, therefore, that there is something to be said in favor of keeping a bull for the service of cows which have aborted, and, when that is not possible, of disinfecting the external genital organs of the bull after he has served such cows. Of course, if the cows can be immunized the same bull might be used for all. We do not think that cows from a clean establishment should be sent even to a clean bull on infected premises, and it is also inadvisable that cows from infected premises should be sent to a bull on a clean establishment.

Destruction of Virulent Material and disinfection of everything contaminated by it.—The immediate disinfection of the virulent materials and contaminated objects is of great importance, more especially as it appears that the natural virus may remain active for a long time outside the body. The soiled litter, dung, exudate, membranes, and fetus should all be removed at once, preferably after they have been treated with caustic lime. After removal they should be soaked in paraffin and burned, or buried in a deep pit, preferably the former. On no account should the fetus and membranes be fed to pigs or dogs. When a fetus is aborted alive, as sometimes happens, it seldom survives long, and it is advisable to kill and destroy it, since it may excrete abundance of virulent material from its intestines if allowed to live. If, however, it be decided not to kill it, it should immediately be isolated. The walls of the stall and the floor should be washed or strewn thickly with caustic lime, or drenched freely with boiling water. The temperature necessary to kill the bacillus is not great, and this simple method of disinfection should prove efficacious. Lastly, the boots, clothing, and hands of attendants should be disinfected by making use of any reliable disinfectant, such as 3 or 4 per cent solution of carbolic acid.

The keeping of a Goat amongst the Cows.—This, we believe can only have had its origin in ignorant superstition, but we feel bound to mention it, as the question of its efficacy has quite frequently been seriously put to us. We would point out that goats themselves can be infected with cattle abortion, and that both male and female goats were on our premises during the greater part of the time occupied with the cattle experiments, and their presence did not prevent animals from aborting.

Preventive Inoculation.—This is still in the experimental stage and definite results are hoped for." (*Abridged.*)

The Committee refrained from making any recommendations in regard to measures to be taken by the Board of Agriculture and Fisheries for the prevention of the disease.

Experience in connection with the beef cattle herd at the Illinois Agricultural Experiment Station with the methods of isolation, careful disposal of infected material, cleaning and disinfection of infected stalls, antiseptic irrigation of the genital passages of cows which had aborted, and antiseptic irrigation of the bull before and after service, together with the use of a special bull for heifers and clean cows, has been very satisfactory. These measures were applied under the direction of Professor H. W. Mumford and Mr. H. O. Allison. During the year previous to the inauguration of these measures a large percentage of the calves were lost by abortion. A decided improvement in respect to the number of calves saved was coincident with the use of the procedures mentioned above. They were applied to each case of abortion as it occurred, until in the course of two years abortions have become very infrequent and the herd is now considered free from the disease. It should be noted, however, that those cows which had aborted were not necessarily disposed of, but after local irrigation treatment until the discharge had ceased, they were bred again. Some of the improvement in the herd has, therefore, doubtless been due merely to the retention of relatively immune cows.

Altho the experience here has been rather fortunate and the results obtained seem to bear some relation to the employment of the measures deemed worthy by the British Committee, we hesitate to state that there was any necessary relation between them, because cattle men have observed somewhat similar improvement in herds without the use of any treatment at all. In other words, there appears to be a tendency for the disease sometimes to die out in a herd or to become quiescent for a year or two. On the other hand, the recommendations of the British Committee supported as they seem to be by our local experience, certainly warrant the recommendation of these measures for use in combating contagious abortion. In any event good results cannot be expected without intelligent, careful, and painstaking work, and it may be that some of the failures in applying these measures have resulted from lack of efficiency in applying them rather than from insufficiency of the measures themselves.

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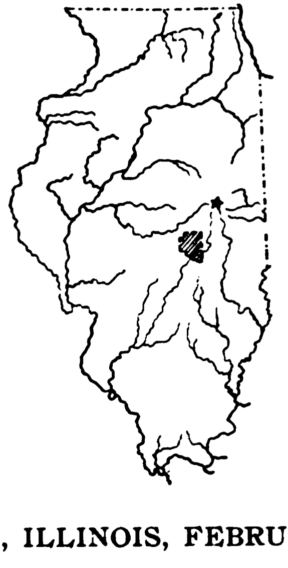
BULLETIN NO. 153—ABSTRACT

COMPARISON OF METHODS OF SAMPLING CREAM FOR TESTING

BY CARL E. LEE AND NELSON W. HEPBURN



URBANA, ILLINOIS, FEBRUARY, 1912

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COMPARISON OF METHODS OF SAMPLING CREAM FOR TESTING[1]

By **CARL E. LEE**, Assistant Chief in Dairy Manufactures,[2] and **NELSON W. HEPBURN**, First Assistant in Dairy Manufactures

Statement.

Bulletin No. 153 contains a report of a series of experiments conducted for the purpose of comparing the various commercial methods of sampling cream for testing, and showing their relation to creamery practice.

The report is based on one year's work carried out in the creamery operated by the Department of Dairy Husbandry, University of Illinois, which had on its list at the time 77 patrons and was making 2500 pounds of butter per week.

The subject matter of the bulletin is largely a comparison of the common commercial methods used in sampling cream for the purpose of determining the percent of fat, and is a statistical comparison of the results obtained by using ordinary composite samples or proportionate composite samples, with those obtained by testing daily samples.

The results are tabulated in 17 separate tables, four of which are distribution tables showing the result of composite sampling, in the case of each of the 77 patrons, when both long and short periods of time are considered.

The remaining tables are summary in nature, giving in terms of totals and averages the results of the various systems described. In this connection additional data are presented showing the results obtained by duplicate testing, taking into consideration the personal factor, and outside influences, such as season and temperature.

The following table is presented as an example of the data which are incorporated in the bulletin. This is a typical table. It shows the results in the case of three representative patrons, and gives, in the respective columns, total pounds of cream, total pounds of fat, and the average test, for each system of sampling during periods of six months and one year, respectively.

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[1] The technical character of this bulletin has made it seem undesirable for general distribution. However, the complete edition, of which this is a condensed outline, will be sent as long as available, upon request. Address Director, Agricultural Experiment Station, Urbana, Illinois.

[2] Now Assistant Professor of Dairying, University of Wisconsin.

TABLE SHOWING COMPARISON IN TERMS OF POUNDS OF BUTTER FAT

Patron number		Total ½ mo. deliveries for 6 mo. period				Total ½ mo. deliveries for yr. period		
		Method of sampling	Pounds cream	Pounds fat	Average test	Pounds cream	Pounds fat	Average test
2	First half of month	Individual	1019.5	275.89	27.06	2808.5	746.79	26.59
		Lee's composite		276.68	27.13		748.54	26.65
		Hepburn's "		277.19	27.19		748.99	26.67
		Proportionate		269.45	26.43			
	Second half of month	Individual	897	163.31	18.21	2605	661.58	25.39
		Lee's composite		162.00	18.06		660.29	25.34
		Hepburn's "		163.20	18.19		662.35	25.42
		Proportionate		161.05	17.95			
31	First half of month	Individual	375.5	126.97	33.80	629	228.66	36.40
		Lee's composite		130.78	34.80		228.71	36.40
		Hepburn's "		131.23	35.00		229.22	36.5
		Proportionate		128.39	34.20			
	Second half of month	Individual	178	63.41	35.60	465	178.77	38.40
		Lee's composite		60.90	34.20		174.25	37.50
		Hepburn's "		61.10	34.30		173.82	37.40
		Proportionate		61.76	34.70			
56	First half of month	Individual	603.5	131.63	21.80	1335.5	236.50	17.70
		Lee's composite		132.37	21.95		234.09	17.55
		Hepburn's "		132.79	22.00		235.43	17.60
		Proportionate		129.09	21.4			
	Second half of month	Individual	471	92.98	19.70	1124.15	307.90	24.80
		Lee's composite		93.49	19.85		311.90	25.10
		Hepburn's "		93.33	19.80		312.22	25.20
		Proportionate		98.63	20.9			

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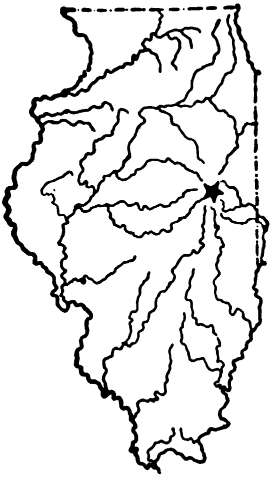
BULLETIN NO. 154

WHAT IS THE MATTER WITH THE ELMS IN ILLINOIS?

By STEPHEN A. FORBES
State Entomologist



URBANA, ILLINOIS, FEBRUARY, 1912

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Summary of Bulletin No. 154

1. Elms dying thruout many towns of southern Illinois, sometimes slowly and sometimes suddenly, the leaves turning brown and falling in summer, and the roots drying up. Pages 1-4.

2. A typical case described. Page 4.

3. Disease observed in fourteen towns scattered thru thirteen counties of southern and western Illinois. Trees not affected if under natural woodland conditions. Page 5.

4. Description of same disease in Kentucky. Pages 5 and 6.

5. Similar disease in central Illinois in 1883. Page 6.

6. Injury caused in part by drouth and unnatural conditions of tree, resulting in starvation; in part by borers in the trunk, attracted by unthrifty state. Former perhaps the primary trouble in most cases. Pages 7-10.

7. Free watering, fertilizing, and mulching of soil necessary, at least in severe drouth. Care required in trimming trees and painting cut surfaces, to prevent infestation. Use of various mixtures suggested as repellents to borers. Pages 11 and 12.

8. Descriptions, figures, and life histories of the elm-borer and the reddish elm snout-beetle. Pages 12-16.

WHAT IS THE MATTER WITH THE ELMS IN ILLINOIS?

BY STEPHEN A. FORBES, STATE ENTOMOLOGIST

(Plates I to VI, and Figures 1 to 4)

The American white elm is doubtless the favorite shade tree thruout Illinois. It is especially valued for its broad and ample shade, its fairly rapid growth, its usual freedom from offensive insects, and its stout resistance to injury by wind storms and sleet; and it is universally admired, also, for its majestic yet graceful form, its picturesque profile, and the irregular, cloudlike masses of its foliage. It is particularly well adapted to streets, boulevards, and park drives; and an avenue of giant elms whose lateral branches arch broadly upwards to meet and mingle overhead is one of the noblest products of the landscape gardener's art.

I especially regret, therefore, to have to call general attention to a fatal affection of this tree now prevailing over a large part of southern Illinois, similar to, and apparently identical with, one which destroyed many elms in the central part of the state some thirty years ago. The character, extent, and cause of this destruction are such as to make it plain either that the elm must receive much more intelligent and assiduous care and treatment than it has heretofore had in this state, or that it must yield its place to some tree more hardy under conditions which it has itself failed to support.

DESCRIPTION OF THE DIFFICULTY

The elm disease (if such it may be called) now prevalent, is first noticed from early summer to autumn—the leaves, first on the terminal twigs and later on the larger branches, ceasing their growth, turning brown, and finally falling. (See Plates I to IV.) This loss is presently followed by the death of the branches themselves, as is shown the following spring when the rest of the tree leaves out. Usually the higher branches are first affected, but the whole top soon seems to blight, and in a year or two the tree is dead. Sometimes this process is greatly shortened, and scores of trees may perish within a single year after the first effects are noticed; and sometimes, on the other hand, it is greatly lengthened, extending thru five or six years, and, in mild cases, even ending in recovery. Altho there may be no definite sign of insect injury anywhere, it is most commonly the case that a thoro search of the trunk and larger branches will show patches of dead bark under which there are two or more kinds of burrowing insect larvæ, or borers. The roots of these trees are often affected somewhat as the branches are; that is, the smaller, terminal, so-called feeding roots die and dry up progressively, the process extending to the larger roots and the base of the trunk.

A TYPICAL CASE

The condition of the roots of trees so affected is well shown by the report of Mr. Lindley M. Smith, my field assistant for southern Illinois, who visited Du Quoin, Perry county, in July of the current year for an examination of elms reported to be dead or dying. This visit was in pursuance of a letter addressed to me by Mr. E. E. Jacobs, mayor of the town, who says, under date of July 8: "At the time the city of Du Quoin was laid out, some fifty years ago, our streets were lined with elm trees. These trees have gotten along nicely up to the present summer, but now there are probably a hundred and fifty trees dead or dying." Mr. Smith reports, July 14: "The elms are in very bad condition, and there are many dead or dying ones all over town. The round-headed borers [Fig. 1] are very thick under the bark on these dying trees, and the people in general seem to suppose that the borers are the cause of all of the damage. I dug out some of the main roots on seven large trees, and while many of the roots were still green for a few feet from the base, I invariably found that the little feeding roots were dead. In some cases the smaller roots had apparently been dead for several days, or perhaps weeks, as they were all discolored and some were almost rotten. We dug one tree out so that all of the roots could be examined. The outer ends of all the roots on this tree were dead, tho some of the main roots were still alive, and the leaves were not yet quite all dead. The tree had no taproot, all the roots spread out from the base of the tree, and none of them were very far beneath the surface. I found no sign of insect work on the roots, but most of the latter simply looked as if they had dried up. The ground was very dry, as there has been no rain that would wet down to the tree roots since some time in April." Similar conditions were found by Mr. Smith at Carbondale, where one tree was dug up, together with a number of roots of other trees, on the campus of the Normal School; all the small feeding roots of these trees were dead, altho there was nothing about them to indicate injury by insects.

DISTRIBUTION OF THE INJURY

Practically identical reports of injury have been received this year, either from my own assistants or from office correspondents, from Cairo, Carbondale, Centralia, Clayton, Du Quoin, Edwardsville, Fairfield, Galatia, McLeansboro, Mt. Vernon, Quincy, Robinson, Sumner, and Vandalia—fourteen towns scattered thru thirteen counties of southern and western Illinois. Doubtless a critical examination of elm trees in towns and on private premises elsewhere would disclose an even more general occurrence of this trouble.

As none of the cases reported were from woodlands, but all were those of more or less isolated trees growing under artificial conditions, I have taken some pains to ascertain whether woodland elms were similarly affected. One of my assistants, Mr. Wesley P. Flint, made in 1909-10 a practically complete reconnaissance of all the forests of southern and western Illinois, including high lands and bottom lands, hills and plains, and the extremes of the state from Jo Daviess to Alexander counties. His object was to make a comprehensive study of insect injuries to forest trees and timber products in this state. In reply to my special inquiry he says: "I have not found elms dying in any numbers in any forest tract that I have examined in the state. This, of course, does not apply to stands of scattered trees around which the ground has been cultivated." Mr. Smith, who was especially instructed to inspect woodland trees about Du Quoin for a comparison of their condition with those in that town itself, reports that he saw a hundred and fifty elms in the woodlands along Reese Creek and Little Muddy Creek bottoms, but found none that were dying, and none that had died during the present summer, altho a few had perished from some cause at some time within the last three years.

The present difficulty with the elm in the southern part of the state is thus clearly one which is virtually limited to trees growing outside the forests, and usually under conditions more or less artificial to the tree—sometimes extremely so, where, for example, the elms are standing in a closely clipped turf beside a paved street.

A KENTUCKY INSTANCE

All the facts in my possession indicate that our Illinois elm disease is identical with one described in 1899 by Professor H.

Garman, Entomologist and Botanist of the Agricultural Experiment Station of Kentucky.[*] "Beginning," he says, "in 1892, and continuing with greater or less frequency ever since, complaints have reached me concerning a diseased condition of elm trees in this State. * * * Previous to 1892 there is every probability that the trouble was under way. It was observed in Massachusetts in 1847, and in Illinois in 1883. * * *

"The first discernible evidence of disease is a loss of the leaves at the ends of twigs, often at the tops of the trees. As the trouble extends towards the trunk, the foliage gradually drops from other parts until finally the tree stands bare. [Plates I to IV.] The fallen leaves may show no mark of insect work, certainly none that could cause them to let go their hold on the branches, and the only thing abnormal about them is a discoloration, sometimes present, like that due to the blight fungus of potatoes, the tips or side regions being more or less extensively black."

AN EARLIER ILLINOIS CASE

As already intimated, what seems to have been a similar trouble with the elms prevailed some time since in the central part of this state. It was in 1883, in fact—the first year of my service as State Entomologist of Illinois—that this matter first came to my notice; and during that and the three following years I studied the diseased elms with considerable care at Normal, Bloomington, and Champaign, publishing a short article on the subject in my third entomological report.[†] I was aided in this work by Professor Garman, who was at that time in my office; and he has had, consequently, an opportunity to compare the Illinois disease with that studied by him even more thoroly in Kentucky.

THE PRESENT SITUATION

My attention was first and most forcibly called to the present situation by a letter addressed to the University of Illinois in 1907 by Hon. John M. Rapp, of Fairfield, in Wayne county, and referred to my office for reply. In this letter he says: "We in this city are troubled with something that is causing the death of the elm shade trees. The matter seems to be growing worse each year. Some of the largest and finest trees have died, and the trouble does not seem to be confined entirely to the oldest and largest trees." In a later letter he says: "The elm trees, not only in this city, where they have been our chief shade tree, but in the surrounding country, are dying from some disease that is a mystery to our people. There is apparently no disease of the leaf—no web formed—but the leaves begin to dry up and to die, and finally, in a few months, the tree is dead. A number of the finest shade trees in the city have gone that way. There are many that now show evidences of the disease."

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[*] "The Elms and Their Diseases." Bull. 84, Ky. Agr. Exper. Station.

[†] Insects Injurious to the Elm. 14th Rep. State Ent. Ill., p. 112.

In consequence of this information I sent to Fairfield in the fall of 1907 Mr. H. E. Hodgkiss, an entomological assistant in my office at the time. As the primary cause of the disease seemed a matter of doubt, and might possibly be a fungous infection, or even cultural conditions merely, Mr. Hodgkiss was accompanied on his trip by Professor T. J. Burrill, of the University of Illinois, who kindly consented to assist us in the solution of the problem. After a thoro examination of several dead and dying trees in and about Fairfield these gentlemen came to the conclusion that the cause was a complex one, but differed in judgment as to the primary factor, Professor Burrill believing it to be the round-headed borer of the elm (*Saperda tridentata,* Fig. 1), which was abundant under the bark of most of the injured trees, and Mr. Hodgkiss concluding, on the other hand, that the original difficulty was in the roots.

CAUSES OF THE INJURY

The condition of the roots described above by Mr. Smith and a general infestation of the trunk and larger branches by borers, are found together at the same time and place, and usually in the same trees. The well-known disposition of the borers generally, and especially of the elm-tree borer, to infest first and most freely trees already suffering from some other cause, adds to our uncertainty concerning the share which these two causes may take in the destruction of our elms. It is probable that sometimes one is primary, and sometimes the other. The root injury may come to a tree already infested by borers, or the borers may come to infest a tree already affected at the roots, each injury intensifying the other, and both together destroying trees which might survive either alone. Even elm trees in the forest are more or less infested by the round-headed borer and other insects of similar habit. Mr. Flint reports, for example, that in his inspection of woodlands, he found this borer abundant in dying trees thruout the state, and the larva of the elm curculio (*Magdalis armicollis,* Fig. 3, 4) even more abundant in the northern counties. Small bark-beetles were also very common in the bark of both dead trees and those otherwise healthy.

The elm in its natural habitat grows in a loose and shaded soil composed of leaf mold to a considerable depth, and does not root deeply. (See Plate VI.) If other trees and the underbrush which afford more or less protection to the elm roots are cut away, and especially if the land is pastured and the soil thus packed, or if, as in the city, the root system is cramped in earth sometimes permeated by escaping gas, too closely packed, unmulched, and unnaturally drained, and exposed for long summer periods to the hot glare reflected from the paved streets, the leaves of the tree in the meantime being constantly exposed to gas and smoke, and covered for weeks with dust from the street, we have an environment for this tree as unnatural as it would be possible to make it and permit the tree to live at all. The feeding roots are thus exposed to drouth, and sometimes remain for weeks at a time about as dry as the dust of the street. The soil is exhausted of plant food, and nothing is done to renovate it. The tree is starved and weakened, the uppermost twigs begin to die, and insects, instinctively attracted to the weaker trees, come in and finish the work. Their injury, at first scarcely perceptible, serves merely to accelerate the decline of the tree, but sometimes, unfavorable conditions having reached a temporary climax, the work of the borers, stimulated rather than retarded by such conditions, quickly overwhelms the tree, girdling its trunk and killing it as if by a sudden stroke.

Professor Garman is sure that in Kentucky insects were not the primary cause of the wide-spread loss of elm trees in 1899 and the years preceding. His discussion of conditions and effects is so instructive and convincing that I quote from it at length.

"The white elm," he says, "has a peculiar way of sending its main roots out close to the surface of the ground. Sometimes a root upon which a tree chiefly depends is covered in places with less than two inches of soil. Roots after leaving the base of the trunk actually turn toward the surface, where they extend for long distances in the rich surface soil. The trees taken up on the college grounds for examination illustrate the point very well. [Plate VI.] The living tree had three main laterally directed roots of this sort. They were vertically flattened for about eight inches and then contracted rather abruptly to two inches in diameter, tapering gradually from this point to their extremities. After leaving the trunk they rose toward the surface and lay for a distance of nineteen feet out from the tree among the roots of clover and grasses. Besides their main roots were a few whip-like roots of the same sort, lying even nearer the surface than the large ones.

The only other roots present were eight small brace roots from one-half to one inch in diameter, which extended downward into the soil at an angle of about 45 degrees. So long as they were uncut the tree stood firmly in place, though the soil was removed for a depth of several feet. The long lateral roots were all cut and still the tree could not be moved until these little roots were severed. The second tree had more of the lateral roots, but they arose and extended outward like those of the first. The brace roots were of the same character and of about the same number.

"Trees with such a root system are adapted to alluvial soils, rich and easily penetrated. A certain amount of moisture is also essential to them. Under natural conditions elms grow among other plants, interspersed with other trees. The ground, besides being rich and from situation moist, is protected during winter by a mulch of dead leaves and in summer by shade and perhaps a tangle of undergrowth. Soil so protected does not give up its moisture quickly. But let such trees be exposed to the heat of the summer sun by cutting away all other trees, or by keeping the grass browsed or mowed closely over their long roots, and they become enfeebled in time and ready to succumb when any sudden and exceptionally severe drought or freeze comes. Even if the removal of our forests had no other effect than exposing the soil to the sun it is probable that such isolated trees would suffer in time. But removal of vast tracts of forest, coupled with tillage and other processes involved in peopling a country, is known to encourage drought in other ways: By favoring a rapid escape of rainfall by surface drainage, a process that is accelerated artificially by ditching, tile draining, and the like, eventually leading to constant late summer droughts from which not only trees but all other plants suffer. A tree with an extensive root system may not show the effect in one year, or in two, but in the course of many years the available food supply becomes exhausted, having been in part leached away by the running waters, and no fresh humus being supplied, the inevitable result is exhaustion for lack of both food and moisture. The effect shows first by the death of tips of branches, the tree not having vitality sufficient to keep up the circulation in the extremities, and the tree becomes 'stag headed,' to use an imported term.

"If one looks about in Bluegrass Kentucky he will see many trees in this condition, oaks, ash and maples. The trouble is of course more or less serious according to the exposure of the roots.

"Not only do trees fail to show signs of suffering immediately after the surface is cleared, but it is known to experienced foresters that for a time they grow more rapidly and appear to be in better condition. This is explained as the result of an increased food supply, due to the removal of competitors, to a more rapid decomposition of humus, which results from exposure to the air, and to increased sunlight. It is only after a considerable period that the final effect of deforesting is felt by the trees and perceived by man. Such results are not restricted to this country, but are known among foresters the world over.

"I take it we are now witnessing some of these effects in Kentucky, and that our elms feel the change most keenly because of their manner of rooting. The debility brought about by unfavorable conditions such as those described is taken advantage of by the elm tree borer* in some cases, which completes the ruin by girdling trees under the rough outer bark."

PROSPECTS OF CONTINUANCE

There is nothing more characteristic of unusual outbreaks of insect injury than their temporary character. Altho it seemed in 1884 that the elms of central Illinois towns would probably all be gone in a few years, their epidemic disease diminished in the following years almost as rapidly as it had developed. Single cases were still to be found ten years later, but many of the affected trees recovered, and there has been, until lately, only an occasional trace of this special trouble in that part of the state since 1895.

In Kentucky also the heavy loss of elms which was the occasion of the bulletin of Professor Garman quoted above has now practically ceased; and in a letter dated June 3, 1910, he says: "Our elms have largely recovered since my bulletin was written, altho a good many of them were lost during the excessively dry period of which the bulletin treated. During the past three years we have had more rainfall than we wanted at times, and the trees everywhere are looking fine."

The case is therefore not as hopeless as it now looks, for the elms of southern Illinois towns, altho the past summer has been a peculiarly trying one. If the weather of the next years is normally moist, it is quite possible that many of the injured trees favorably situated may recover, and that the general condition of the elms thruout the country will become greatly improved. If, however, weather conditions should continue unfavorable, the injury will go on in all probability to still greater extremes. In any event methods of prevention and remedy are important to all who value their

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"*Two other beetles belonging to the same family as the elm borer, were reared by me [Garman] some years ago from diseased elms. They are *Dularius brevilineus* and *Xylotrechus colonus*."

trees, especially as the causes of the present trouble are to be found in great measure in previous mismanagement.

REMEDY AND PREVENTION

The truth is that our shade trees have commonly been treated as if, unlike any other crop we raise, they needed neither care nor cultivation, but once set out would take care of themselves forever. This is not true, as we now know, for even forest trees growing under native conditions; and it is peculiarly false for trees planted in more or less unnatural situations, and for those whose original surroundings have been changed materially for the worse. Here especially the elm must be watched and cared for; fed, watered, and protected; relieved from the attacks of its insect enemies, and surgically treated to heal the wounds they have made. The amount of attention it will require will vary, of course, with its situation, including the condition of other trees on adjacent premises. Indeed, no really satisfactory program of protection and maintenance can be worked out except by cooperation of all concerned. A single badly infested tree, kept because of the indifference of its owner, may be a constant menace to all the other elms in its neighborhood, however intelligently they may be cared for.

The main effort must be at first to supply to endangered trees, and especially to those beginning to fail, the water and plant food, a lack of which is the most serious feature of their situation. Well-rotted stable manure spread generously around the tree as far as its roots extend, with an occasional free watering of the soil during periods of severe drouth, will meet these requirements. If the manure can be left during dry periods as a mulch, the chances of the tree will be greatly improved. The watering must not be a mere surface sprinkling, but should soak the ground to a depth of several inches.

When it is necessary to trim a tree, superfluous branches should be cut or sawed smoothly away at their very beginning. To cut or hack them off irregularly, leaving projecting stubs to dry up and decay, is simply to invite the attacks of borers by offering them a favorable place of deposit for their eggs. For the same reason dead, dying, or badly injured limbs should be promptly cut out and burned.

This is as good a place as any to enter an emphatic protest against the practice of topping or pollarding trees like the elm, not only because their natural beauty is forever destroyed by the process, but also because the tree is peculiarly exposed by it to fatal infestation by its most destructive insect enemies.

Further protection against borers may be given by a thick coat of paint applied to cut surfaces and repeated after the first coat is dry. Any paint will do which is made of linseed oil and lead. Ordinary ready-made paints are nearly useless for this purpose, since they are likely to crack and scale off. As a general preventive of borer infestation, the trunk of the tree and the larger branches may be painted with a mixture intended to prevent the laying of the eggs. Some of the mixtures recommended are prepared as follows: To a gallon of soft soap add half a gallon of hot water and a pint of crude carbolic acid, or a half pint of the refined acid, stirring the latter thoroly in and leaving the mixture over night. Then dilute with eight gallons of water and apply with a whitewash brush. Or, to a saturated solution of washing soda add soft soap to make a thick paint, and stir in a pint of crude carbolic acid and half a pound of Paris green to each ten gallons of the wash. Or, in six gallons of a saturated solution of washing soda dissolve a gallon of soft soap, add a pint of carbolic acid, mixing well, slake enough lime in four gallons of water to form a thick whitewash as it is added to the foregoing, and finally stir in thoroly a half pound of Paris green. One or the other of these substances should be applied, as frequently as may be necessary to keep the bark moist, from the middle of May to the end of July.

THE INSECTS CHIEFLY CONCERNED

Of all the many insect enemies to the elm in Illinois, much the most destructive is the "round-headed" borer commonly known to entomologists as the elm-borer (*Saperda tridentata*). Even more abundant than this, but less injurious, is a much smaller burrowing grub, the larva of the reddish elm snout-beetle (*Magdalis armicollis*). It is the common elm-borer, working in the bark and the sap-wood of the elm, to which the present condition of our dead or dying trees is most commonly attributed by those searching for a cause. It is a common belief, however—difficult to prove, it is true, and at best a matter of intelligent opinion—that this beetle attacks by preference trees already suffering from some disease or other crippling condition. It would be easier to make sure that this is true if it were not for the fact that it is difficult to detect the beginnings of injury by this insect. Often the first notice one has of its presence is a general failure of the tree, due to an infestation already extensive and long continued; and whether this failure began before the borer injury or was caused by it, one can not positively tell. This is, indeed, a matter of little practical importance, since one must proceed in the same way whichever view he takes. That the elm *snout-beetle* infests dying trees in preference to healthy ones, can not be doubted, for the larva is abundant in the dead wood of a dying tree but occurs very rarely in the living tissue.

THE ELM-BORER

Saperda tridentata Oliv.

In the larval or boring stage this elm insect may be readily recognized by those at all familiar with the round-headed borer of the apple, because of the close resemblance of the two. · They belong, in fact, to nearly related species of the same genus.

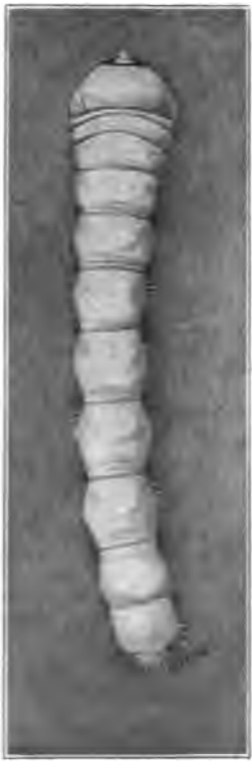

Fig. 1. The Elm-borer, *Saperda tridentata*, larva. (Enlarged 5 diameters.)

The full-grown boring larva (Fig. 1) is a footless grub a little over an inch in length, white or yellowish white, thickest in front, and with the head only about half as wide as the first segment behind it. The body is slightly flattened from above downward, with a rather pronounced fold along the sides. The first segment is about twice as broad as long, and has upon its upper surface a pale, horny, oblong, transverse shield or cover about two thirds as long as wide. This is roughened on the posterior half, but is elsewhere smooth. On the upper side of each remaining segment is an ovate, roughened, transverse area, slightly convex in front and slightly concave behind.

The pupa, which may be found in a cell beneath the bark, is yellowish white, about half an inch long, and with slender antennæ lying along each side and bent forward over the breast.

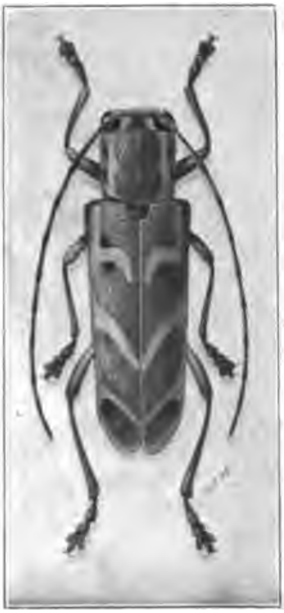

Fig. 2. Adult, or beetle, of the Elm-borer, ***Saperda tridentata.*** **(Enlarged 4 diameters.)**

The parent beetle (Fig. 2) is of a grayish color, due to a very fine gray down which densely clothes the surface. On each side of the thorax and on each wing cover is a submarginal reddish or yellowish stripe, and from each of these stripes three oblique bands project inward and backward to a variable distance in different specimens. Sometimes they extend across the wing cover to meet the corresponding bands on the opposite side, and sometimes they are short oblique branches only. There are often two black spots on each side of the thorax, and three on each wing cover.

Strangely enough, the life history of this abundant insect has never been worked out, but there is good reason to suppose that it extends over two or three years. Indeed, in the northern part of the area of distribution of the species, as many as three distinguishable sizes of the larvæ may be found at one time in the mines under the bark, each apparently representing a different generation. The eggs are deposited in June and July and possibly later, as the beetles are abroad until towards the middle of August. The young grub, after hatching, works its way under the bark, making a serpentine burrow as it feeds, which increases in size with the growth of the larva and in course of time may completely girdle the tree. When the larvæ are full-grown they change to the pupa in the early part of the year, and the beetles begin to appear in May.*

This species has been recorded from Vermont, Canada, and Wisconsin, to Pennsylvania, Kentucky, Illinois, and Iowa. It seems to have a general distribution thruout the northeastern United States.

THE REDDISH ELM SNOUT-BEETLE

Magdalis armicollis Say

A small boring grub about a quarter of an inch long or less, frequently associated with the round-headed borer of the elm often occurs in immense numbers in the recently dead wood of the elm, and sometimes extends its burrows into the still living tissue adjacent. It is a small, plump, entirely footless, whitish grub, lying partly curled up in the usual grub fashion when at rest. The head is small, but the three segments back of the head are noticeably

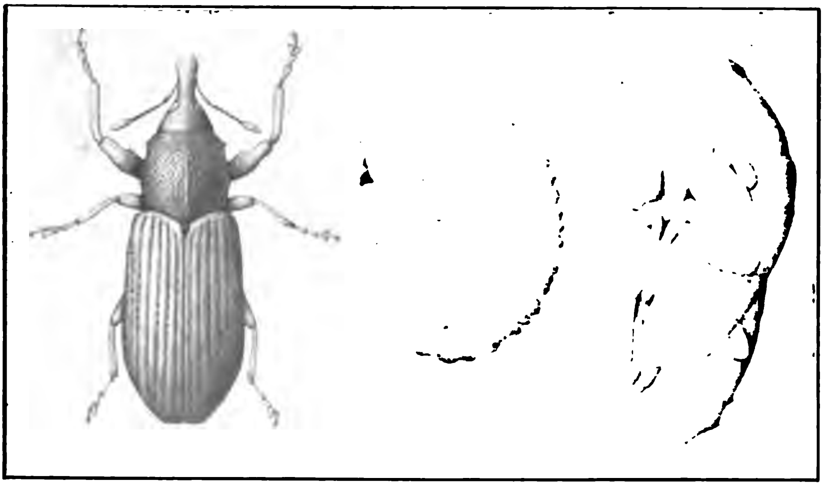

Fig. 3. Elm Snout-beetle, *Magdalis armicollis*: larva, pupa, and adult beetle. (Enlarged 8 diameters.)

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*My office collections of the beetles range from May 19 to August 8.

swollen and about one twelfth of an inch thick. The remainder of the body is more slender, slightly tapering to the smoothly rounded posterior end. The head is pale brown, and the mandibles and the narrow front border of the clypeus are dark, in decided contrast with the labrum, which is whitish. The first segment back of the head is faintly brownish, shining except for a dull pubescent ridge along the hind border. The remaining segments, except those near the posterior end, which are smoother, bear two such dull ridges. On the abdominal segments these ridges extend to the spiracles on each side, and behind them is an additional shorter ridge of similar appearance. The folds beneath the head are also dull pubescent.

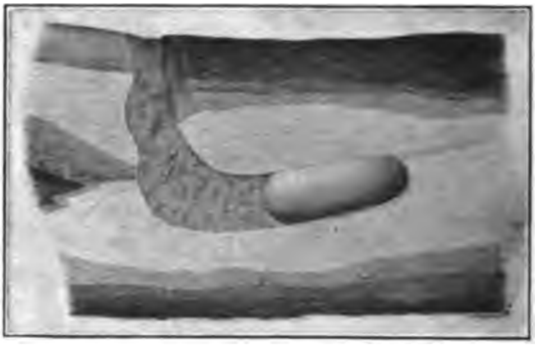

Fig. 4. Elm twig with bark cut away to show burrow of *Magdalis armicollis*. (Enlarged 3 diameters.)

The beetles, which develop beneath the bark and escape from it by eating small round holes to the surface, are from an eighth to a quarter of an inch in length, the sexes differing to such an extent that they were originally described as separate species. The male is, in fact, decidedly smaller than the female, darker beneath, and with a much more marked contrast in color between the wing covers and the thorax. The wing covers are yellowish, or pale reddish brown, and are each marked with nine deep longitudinal, coarsely punctured, grooves. The thorax and the head are decidedly darker, especially in the male, in which they are frequently black. The thorax is narrower than the wing covers, broadly rounded laterally and very densely punctured above and on the sides, with a more or less evident smooth median raised line. The body beneath is pale reddish brown in the female, and black in the male. The projecting, slightly curved snout is about as long as the thorax, and bears the antennæ near its tip.

The larvæ pupate in spring within the tree, and the beetles emerge in about three weeks, pairing and laying their eggs in May and June.

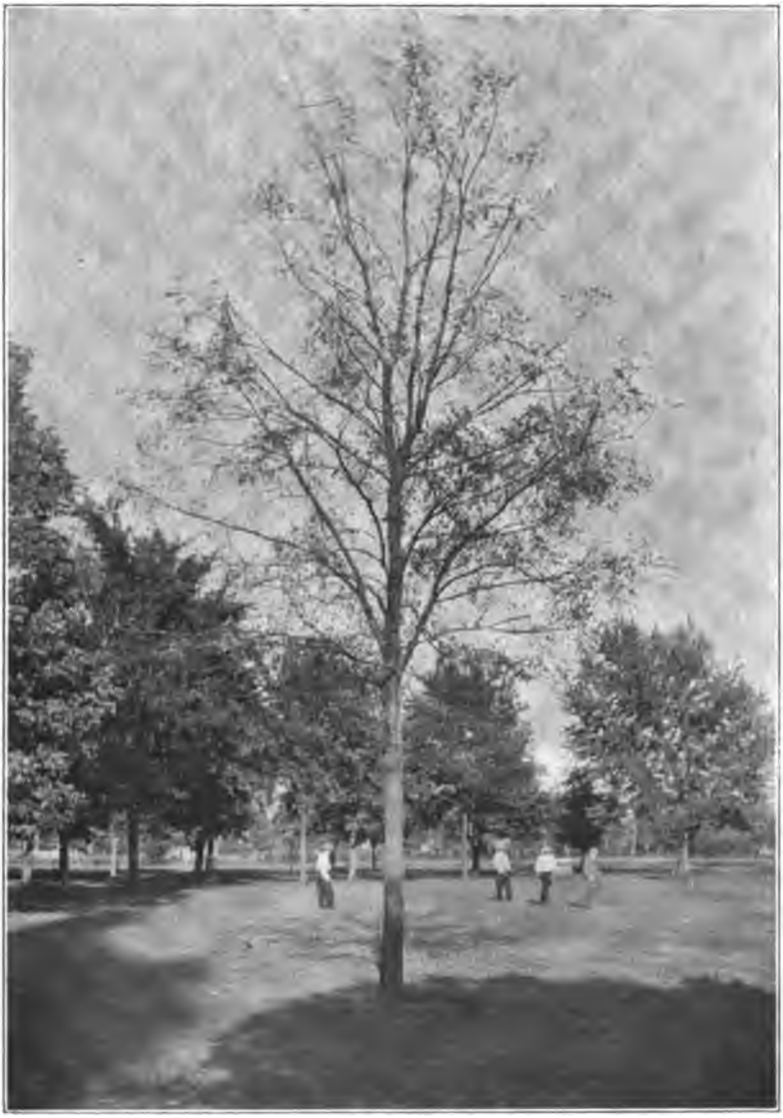

PLATE I.

ELM-TREE --DIED DURING SUMMER OF 1911. NORMAL SCHOOL CAMPUS, CARBONDALE, SEPTEMBER 20, 1911.

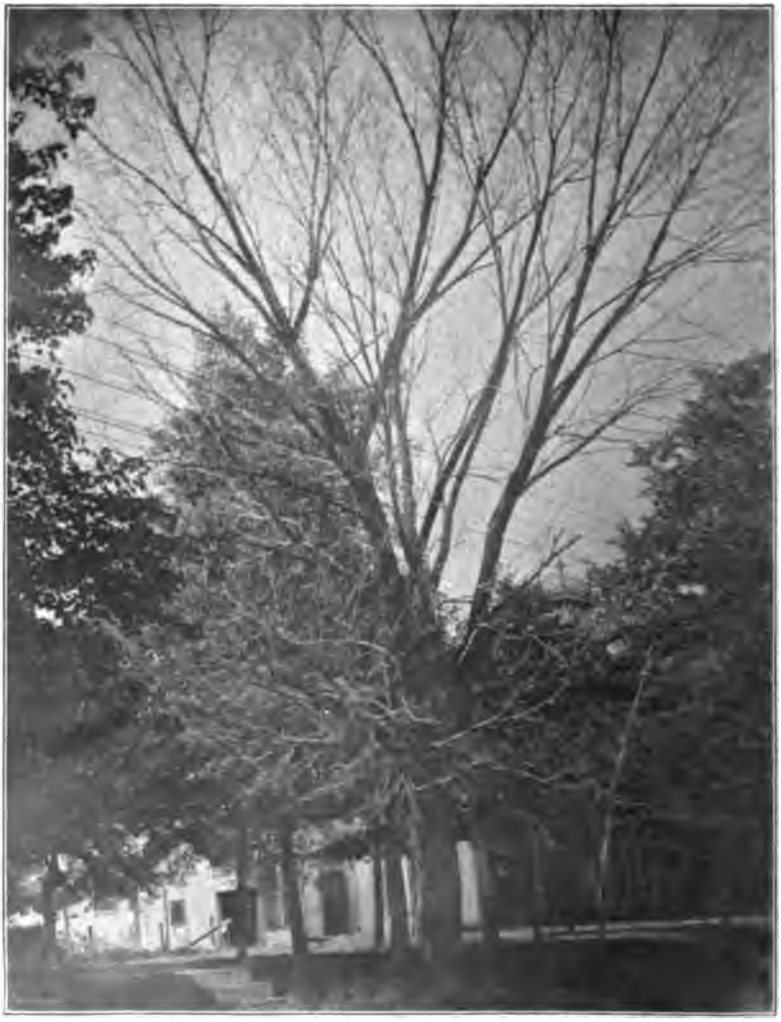

PLATE II.

ELM-TREE—DIED DURING SUMMER OF 1911. NORMAL AVENUE, CARBONDALE, SEPTEMBER 20, 1911.

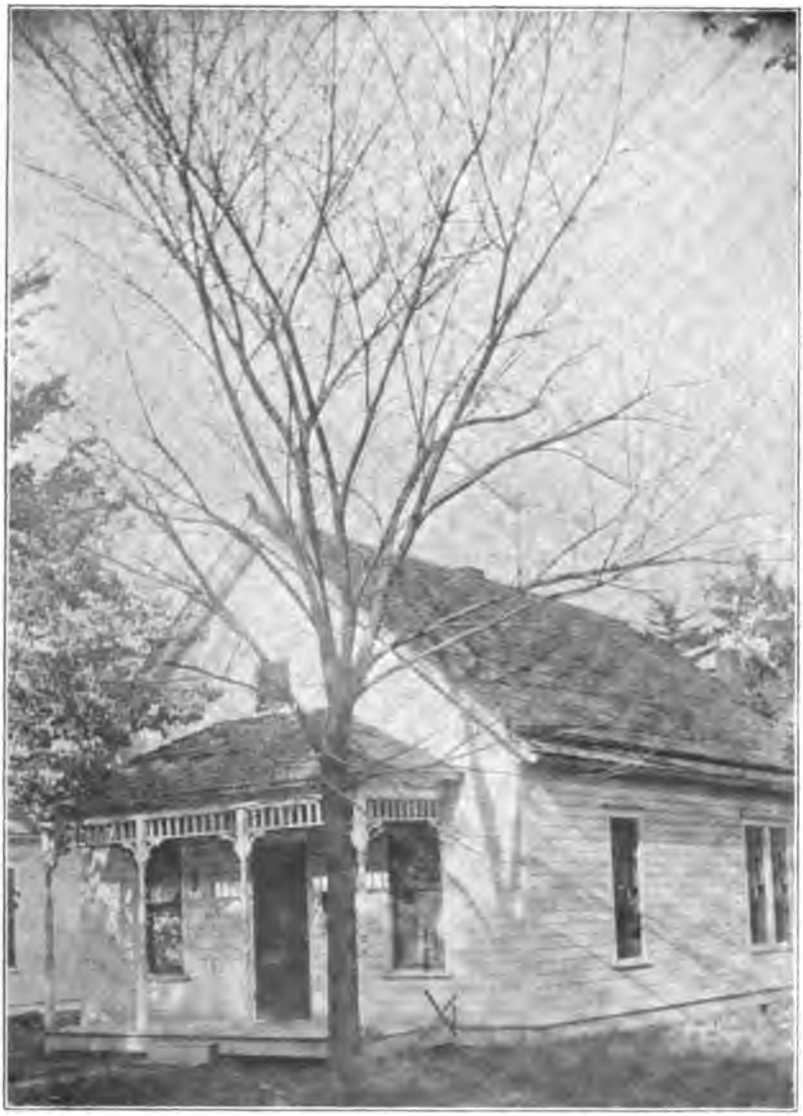

PLATE III.

ELM-TREE—DIED DURING SUMMER OF 1911. NORMAL AVENUE, CARBONDALE, SEPTEMBER 20, 1911.

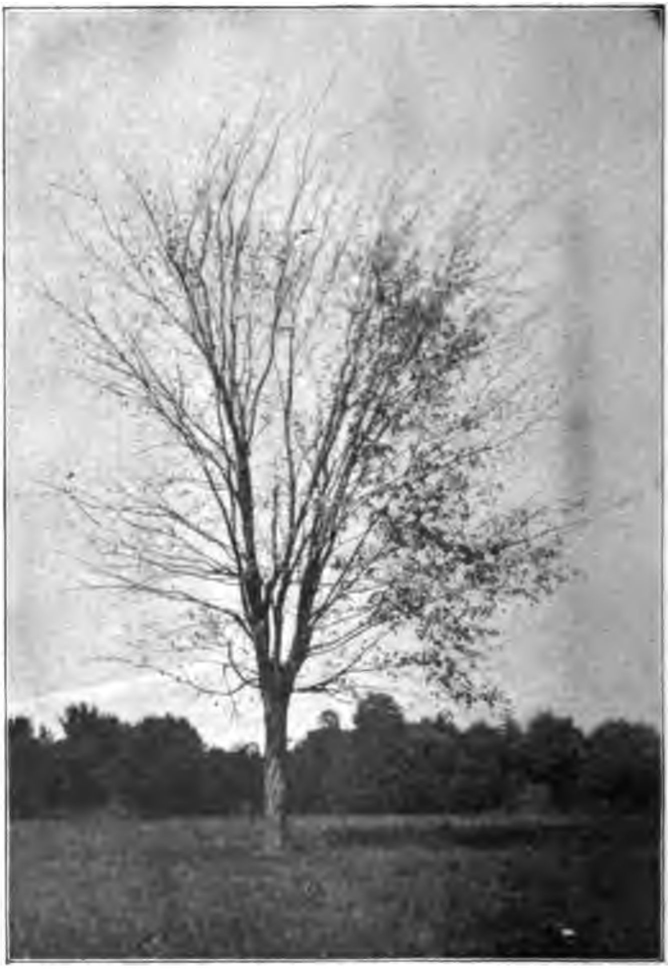

PLATE IV.

A DISEASED ELM GROWING ON THE GROUNDS OF THE KENTUCKY STATE UNIVERSITY. PHOTOGRAPHED AUGUST 28, 1899. (FROM PROF. H. GARMAN.)

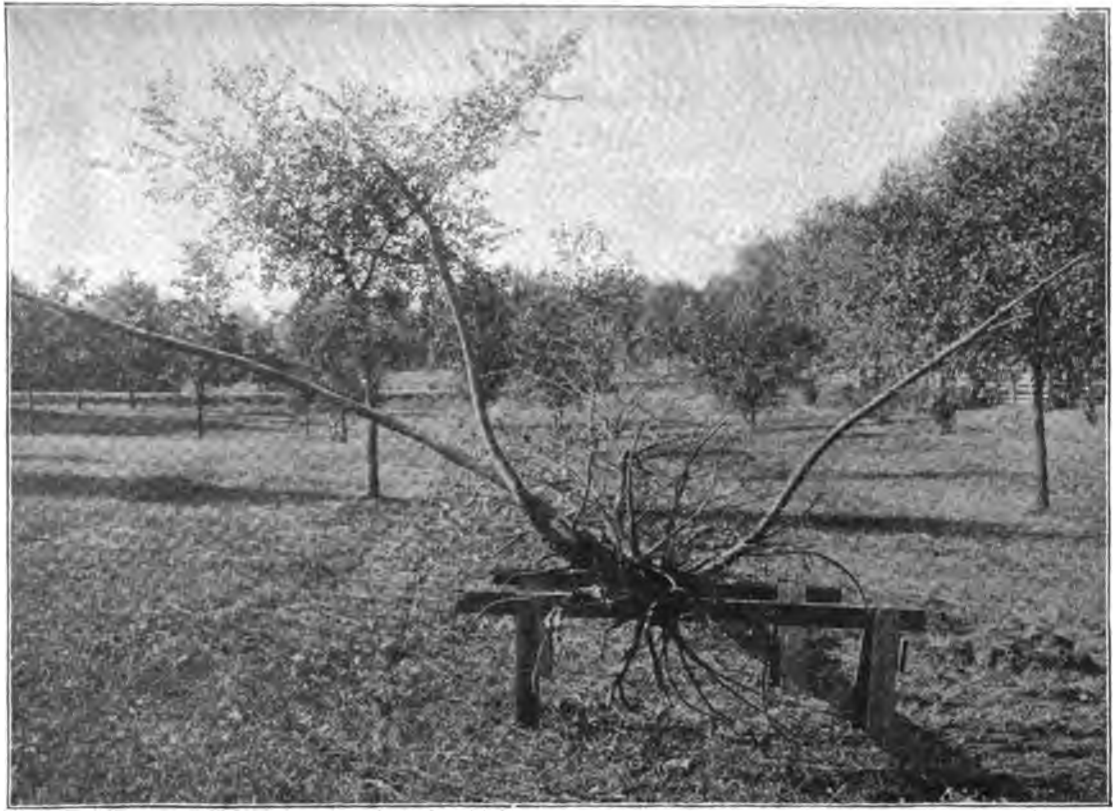

PLATE V.

Roots of diseased white elm seen from beneath. (From Prof. H. Garman.)

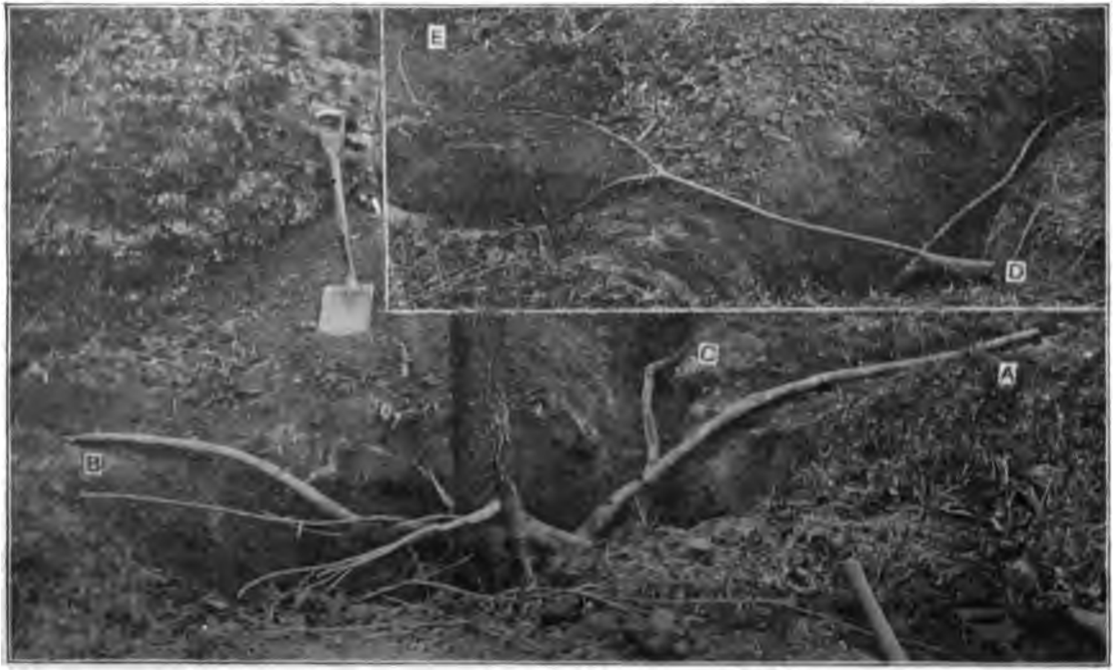

PLATE VI.

ROOTING HABIT OF ELM, FROM SAME TREE AS FIG. 4: A, B, C, THE THREE MAIN LATERAL ROOTS; D, CONTINUATION OF ROOT C; E, EXTREMITY OF SAME ROOT, 19 FEET FROM THE TRUNK. (FROM PROF. H. GARMAN.)

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CIRCULAR NO. 155

PLANT FOOD IN RELATION TO SOIL FERTILITY*

By Cyril G. Hopkins

I take it that the only justification for me to review the subject of plant food in relation to soil fertility or crop production is the fact that recent publications from the federal Bureau of Soils have strongly affirmed that there is no necessity of applying plant food in the restoration and maintenance of soil fertility. Two principal questions are raised: First, Does plant food applied increase crop yields in harmony with recognized soil deficiencies and crop requirements? Second will the rotation of crops maintain the productive power of the soil by avoiding injury from possible toxic excreta from plant roots? I shall try to present facts and data and exact quotations rather than my own opinions concerning these questions of such fundamental importance in relation to systems of permanent agriculture.

In 1804 DeSaussure, the French scientist, first gave to the world a correct and almost complete statement concerning the sources of the food of plants, including not only the confirmation of Senebier's discovery of the fixation of carbon in the formation of carbohydrates, but also the evidence of plant requirements for the essential mineral elements secured from the soil.

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*An address read before the Botanical Society of America and the Botanical Section of the American Association for the Advancement of Science, in joint session, at Washington, December 27, 1911.

Sir Humphrey Davy and Baron von Liebig did much to popularize this information during the following half century; and they were followed by Lawes and Gilbert, whose extensive and long-continued investigations furnished the needed proof that the soil must furnish nitrogen as well as the mineral elements; and finally, only twenty-five years ago, Hellriegel discovered the symbiotic relationship between legumes and bacteria which gives access to the inexhaustible supply of atmospheric nitrogen for soil enrichment.

Briefly, it might be said that for nearly a century the world of science has accepted and taught, and the world of advanced agricultural methods has practiced, the doctrine that soil fertility maintenance and soil enrichment require the restoration or addition of plant food, including particularly phosphorus and nitrogen, which are most likely to become deficient in normal soils, potassium where needed, and sometimes lime or limestone, which always supplies calcium, and magnesium as well if dolomitic limestone be used. Of the other five essential elements, carbon and oxygen are secured from the carbon dioxid of the air, hydrogen from water, and iron from the inexhaustible supply in the soil; while the sulfur brought to the soil in rain and otherwise from the atmospheric supply, resulting from combustion and decomposition of sulfur-bearing materials, supplemented by the soil's supply and by that returned in crop residues, appears to be sufficient to meet the plant requirements and the loss by leaching.

After nearly a century of the increasing agricultural practice of this doctrine on much of the farm land of Germany, France, Belgium, Holland, Denmark, and the British Isles, those countries have approximately doubled their average acre-yields. The ten-year average yield of wheat in the United States is 14 bushels per acre, while that in Europe has gone up to 29 bushels in Germany, to 33 bushels in Great Britain, and to more than 40 bushels per acre in Denmark. The annual application of phosphorus even to the soils of Italy has already become greater than the phosphorus content of all the crops removed. The exportation of our highest grade phosphate rock from the United States to

Europe now exceeds a million tons a year, carrying away from our own country twice as much phosphorus as is required for the annual wheat crops of all the states, and millions of acres of farm land in our own Eastern States have already been agriculturally abandoned, because of depleted fertility and reduced productive power; so that it is now impossible for our Congressmen to enter the Capitol of the United States from any direction without passing abandoned farms.

Ultimate analysis has shown that the most common loam soil of southern Maryland,* almost adjoining the District of Columbia, contains only 160 pounds of phosphorus, 1,000 pounds of calcium, and about 900 pounds of nitrogen in two million pounds of surface soil, corresponding approximately to an acre of land 6 ²/₃ inches deep. The clover crops harvested from the rich garden soil at Rothamsted in eight consecutive years removed more phosphorus and calcium from the soil than the total amounts contained in the plowed soil of this wornout Maryland land, whose total nitrogen content is also less than would be required for seven such crops of corn as we harvest on good land in the central west, which, however, contains ten times as much of these plant foods as the depleted Maryland soil.

During the last ten years our population increased 21 percent, the same as during the preceding decade, while the acreage of farm lands increased less than 5 percent, and the federal government reports† all future possible increase in farm land at only 9 percent of our present acreage.

Average crop yields for four 10-year periods are now reported by the United States Department of Agriculture. A comparison of two 20-year averages shows increased acre-yields of 1 bushel for wheat and ½ bushel for rye, while the yield of corn has decreased 1½ bushels and the yield of potatoes has decreased 7 bushels per acre, by 20-year averages. These crops represent our greatest sources of human food, even our supply of meat being largely dependent upon the corn crop. Less than 20-year averages are not trustworthy for a consideration of any small increase or decrease in yield per acre. It should be noted that during the last forty years vast areas of virgin wheat land have been put under cultivation, including the Dakotas, which now produce more wheat than all the states east of the Mississippi, save only Indiana and Illinois.

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*See "Leonardtown loam", Bureau of Soils Bulletin 54, and "Field Operations of the Bureau of Soils" in Reports for 1900 and 1901; or see pages 138 to 142 of Hopkins' "Soil Fertility and Permanent Agriculture", Ginn & Company, Boston.

†See Circular No. 38, Office of the Secretary, United States Department of Agriculture.

A comparison of the last five years with the average of the five years ending with 1900 shows that our wheat exports decreased during the decade from 198 million to 116 million bushels, and that our corn exports decreased from 193 million to 57 million bushels.

Thus we have fed our increasing population not by increasing our acre-yields, but by a slight increase in the acreage of farm land and by a large decrease in our exportation of food stuffs; and the fact must be plain that before another decade shall have passed we shall reach the practical limit of our relief in both of these directions.

Indeed, a most common subject already discussed in the press and investigated by national, state and city authorities during the last three or four years is the high cost of plain living.

With these facts and statistics before us, let us consider the actual results secured from field and laboratory investigations:

Where wheat has been grown every year since 1844 on Broadbalk Field at Rothamsted, England, the average yield for fifty-five years has been 12.9 bushels per acre on unfertilized land, 35.5 bushels where heavy annual applications of farm manure have been made, and 37.1 bushels per acre where slightly less plant food has been applied in commercial form.

Barley grown every year on Hoos Field at Rothamsted has produced, for the same fifty-five years, an average yield of 14.8 bushels on unfertilized land, 47.7 bushels with farm manure, and 43.9 bushels where much less plant food was applied in commercial form.

Potatoes grown for twenty-six consecutive years, also on Hoos Field at Rothamsted, produced, as an average, 51 bushels per acre on unfertilized land, 178 bushels where farm manure was used (reinforced with acid phosphate during the first seven years), and 203 bushels where plant food was applied in commercial form. The first year of this investigation the unfertilized land produced 144 bushels, land receiving farm manure alone produced 159 bushels, and land fertilized with commercial plant food produced 328 bushels per acre.

Director A. D. Hall, of the Rothamsted Experiment Station, makes the following statement on pages 95 and 96 of his book on "The Rothamsted Experiments":

> "On the plots receiving farmyard manure, and even on those receiving only a complete artificial manure, the crop was maintained in favorable seasons. No falling-off was observed which could be attributed to the land having become 'sick' through the continuous growth of the same crop, or through the accumulation of disease in the soil."

In commenting upon these same experiments, Milton Whitney, Chief of the United States Bureau of Soils, makes the following statement in Farmers' Bulletin No. 257, page 14:

> "One of the most interesting instances going to show that toxic substances are formed and that what is poisonous to one crop is not necessarily poisonous or injurious to another is a series of experiments of Lawes and Gilbert— the growing of potatoes for about fifteen years on the same field. At the end of this period they got the soil into a condition in which it would not grow potatoes at all. The soil was exhausted, and under the older ideas it was necessarily deficient in some plant food. It seems strange that, under our old ideas of soil fertility, if the soil became exhausted for potatoes, it should grow any other crop, because the usual analysis shows the same constituents present in all of our plants, not in the same proportion, but all are present and all necessary, so far as we know. This field was planted in barley, and on this experimental plot that had ceased to grow potatoes they got 75 bushels of barley."

If, now, we turn to the actual records of the Rothamsted experiments we find that the first crop of barley grown after twenty-six years of potatoes was 33.2 bushels per acre on unfertilized land, only 24.8 bushels where minerals alone had been used and the soil depleted of nitrogen by the potato crops, 67 bushels per acre where minerals and nitrogen had been used, and 72.4 bushels where farm manure had been applied for twenty-six years. We also find, in strict harmony with Director Hall's statement, that the largest average yield of potatoes from the farm manure plots (3 and 4), either for one year or for five years, was secured after potatoes had been grown on the same land for more than fifteen years.

On permanent meadow land at Rothamsted, the average yield of hay for fifty years was 1¼ tons per acre on unfertilized land, and more than 4 tons per acre on land heavily fertilized with commercial plant food. During the last ten years of this fifty-year period the unfertilized land has produced an average yield of 1863 pounds of hay, while the fertilized land has produced 8490 pounds per acre.

On Barn Field at Rothamsted, mangels were grown for thirty years. The average yield per acre was 4¼ tons on unfertilized land, 19½ tons where farm manure had been applied, and 29 tons per acre where the farm manure had been reinforced with nitrogen and phosphorus in commercial form.

In 1902 the University of Illinois began a series of experiments on the common corn-belt prairie land in McLean county, on a field which had grown no wheat for thirty-two years. We first grew wheat in 1905. Four plots not receiving phosphorus produced respectively, 28.8 bushels, 30.5 bushels, 33.2 bushels and 29.5 bushels of wheat per acre; while four other plots which differed from these only by the addition of phosphorus, at the rate of 25 pounds of that element in 200 pounds of steamed bone meal per acre per annum, produced 39.2 bushels, 50.9 bushels, 37.8 bushels, and 51.9 bushels, respectively per acre. Six year later wheat was again grown on this land, when the four plots not receiving phosphorus produced, respectively, 22.5 bushels, 25.6 bushels, 21.7 bushels, 27.3 bushels, per acre, and the other four plots, which differ from these in treatment only by the phosphorus applied during the ten years, produced 57.6 bushels, 60.2 bushels, 54.0 bushels, and 60.4 bushels, respectively, of wheat per acre, this being the second crop of wheat grown on this land in forty years.

This most common prairie land of the Illinois corn belt contains 600 pounds of phosphorus and 18,000 pounds of potassium per million of surface soil, while one million pounds of the subsoil contain 450 pounds of phosphorus and 27,000 pounds of potassium. This is the type of soil on which, as an average of four different tests each year under four different conditions of soil treatment, the addition of phosphorus produced an increase in yield per acre of 9.6 bushels of corn in 1902, of 17.8 bushels of corn in 1903, of 14.8 bushels of oats in 1904, of 14.4 bushels of wheat in 1905, of 1.46 tons of clover* in 1906, of 18.8 bushels of corn in 1907, of 17.3 bushels of corn in 1908, of 15.2 bushels of oats in 1909, of 2.56 tons of clover* in 1910, and an average increase of 33.8 bushels of wheat per acre in 1911.

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*Average of two tests (See Illinois Soil Report No. 2, pages 17, 39).

As an average of four similar tests during the ten years, applications of potassium (costing the same as phosphorus) increased the yield of corn by 3.1 bushels, decreased the yield of oats by 2.3 bushels, decreased the yield of clover by 70 pounds per acre, and increased the yield of wheat by .1 bushel per acre, these being the general average results from the four years of corn and from two years each of oats, clover, and wheat.

If now we turn to the extensive peaty swamp soil of northern and north-central Illinois, we find by analysis that it contains in one million pounds of the surface soil 1960 pounds of phosphorus and 2930 pounds of potassium, or more than three times as much phosphorus and less than one-sixth as much potassium as the common prairie. We also find that, as an average of triplicate tests each year, potassium increased the yield of corn per acre by 20.7 bushels in 1902, by 23.5 bushels in 1903, by 29.0 bushels in 1904, and by 36.8 bushels in 1905; while the addition of phosphorus produced a decrease of .1 bushel in 1902, and an increase of .9 bushel in 1903, of 3.9 bushels† in 1904, and of .3 bushel in 1905.

As an average of the results from twenty plots of unfertilized land in the Pennsylvania rotation experiments with corn, oats, wheat, and hay (clover and timothy mixed), the crop values in two consecutive 12-year periods decreased by 26 percent; while, as an average of the twenty-four years, the crop values were increased 62 percent by farm manure and 65 percent with commercial plant food, as compared with the results from unfertilized land.

The records from the Agdell rotation field at Rothamsted show that as an average of the turnips, barley, clover (or beans), and wheat the yields decreased on unfertilized land by 42 percent measured by the results from two consecutive 32-year periods; and, if we span a 60-year period, we find that the yield of turnips on unfertilized land was 10 tons per acre in 1848 and less than ½ ton in 1908; that the barley yielded 46.5 bushels in

---

*Average of two tests (See Illinois Soil Report No. 2, pages 17, 39).

†Irregular insect injury in 1904 (See Illinois Bulletin 123, pages 251, 252).

1849 and only 10 bushels per acre in 1909; the clover produced 2.8 tons in 1850 and less than 1 ton per acre in 1910; while the wheat following clover produced 29.7 bushels in 1851 and 24.5 bushels in 1911.

The application of plant food (for the turnip crop only) in the same rotation over a period of sixty-four years increased the average yield of turnips from 1¼ tons to 17½ tons per acre, increased the yield of the barley following from 24.4 to 38.5 bushels, then increased the average yield of legumes from 1945 pounds to 4413, and increased the yield of wheat after legumes from 25 to 34.8 bushels, as compared with the unfertilized land.

If, again, we span the sixty years, we find that on the fertilized land the yield of turnips was 12½ tons in 1848 and 17½ tons in 1908; that barley produced 35.9 bushels in 1849 and 33.4 bushels in 1909; that clover produced 3½ tons in 1850 and 4¼ tons in 1910; while wheat yielded 30.3 bushels in 1851 and 38 bushels per acre in 1911.

Thus, the records show that during the last four years, following a sixty-year period, the plant food applied has increased the yield of wheat by 55 percent, increased the barley by 234 percent, and the clover by 340 percent; while the yield of turnips on the fertilized land was 49 times as great as on the unfertilized land.

With these facts in mind we may well consider the following statements from Whitney in Farmers' Bulletin 257:

> "Apparently, these small amounts of fertilizers we add to the soil have their effect upon these toxic substances and render the soil sweet and more healthful for growing plants. We believe it is through this means that our fertilizers act rather than through the supplying of food to the plant." (Page 20.)
>
> "There is another way in which the fertility of the soil can be maintained; viz., by arranging a system of rotation and growing each year a crop that is not injured by the excreta of the preceding crop; then when the time comes around for the first crop to be planted again the soil has had ample time to dispose of the sewerage resulting from the growth of the plant two or three years before...... Barley will follow potatoes in the Rothamsted experiments after the potatoes have grown so long that the soil will not produce potatoes. The barley grows unaffected by the excreta of potatoes, another crop follows the barley, and the soil is then in condition to grow potatoes again.

"In other experiments of Lawes and Gilbert they have maintained for fifty years a yield of about 30 bushels of wheat continuously on the same soil where a complete fertilizer has been used. They have seen their yield go down where wheat followed wheat without fertilizer for fifty years in succession from 30 bushels to 12 bushels, which is what they are now getting annually from their unfertilized wheat plot. With a rotation of crops without fertilizers they have also maintained their yield for fifty years at 30 bushels, so that the effect of rotation has in such case been identical with that of fertilization." (Pages 21, 22.)

If we turn to the Rothamsted data, we find the first recorded yield of wheat on the unfertilized plot on Broadbalk Field was not 30 bushels, but ony 15 bushels; that the average of the first eight years was 17.4 bushels; that the best fertilized plot on the same field has averaged not 30 bushels, but 37.1 bushels for fifty-five years; that, as stated above, the wheat grown in rotation, following a leguminous crop, has averaged not 30 bushels, but 25 bushels on unfertilized land, and 34.8 bushels where fertilizers were applied for turnips three years before.

The following pertinent quotations are from Whitney and Cameron in Bureau of Soils Bulletin 22:

"In England and Scotland it is customary to make an allowance to tenants giving up their farms for the unused fertilizers applied in previous seasons. The basis of this is usually taken at 30 to 50 percent for the first year, and at 10 to 20 percent for the second year after application; but, in the experience of this Bureau there is no such apparent continuous effect of fertilizers on the chemical constitution of the soil." (Page 59.)

"It appears further that practically all soils contain sufficient plant food for good crop yield; that this supply will be indefinitely maintained." (Page 64.)

In Bureau of Soils Bulletin 55, by Whitney, entitled "Soils of the United States", issued in 1909, we find under the heading "Permanency of Soil Fertility as a National Asset", the following summarized statements:

"The soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that cannot be exhausted; that cannot be used up." (Page 66.)

"From the modern conception of the nature and purpose of the soil it is evident that it cannot wear out, that so far as the mineral food is concerned it will continue automatically to supply adequate quantities of the mineral plant food for crops." (Page 79.)

"As a national asset the soil is safe as a means of feeding mankind for untold ages to come." (Page 80.)

As stated in the beginning, I have not planned to discuss the subject of plant food in relation to soil fertility; but I felt it a duty as well as an honor to be permitted to accept a place on your program; and I have placed before you some most important and trustworthy data bearing upon the question. I have presented some statistics for consideration in connection with the gravest problem which now confronts America; namely, the problem of restoring American soil and of maintaining American prosperity. I have quoted accurately and fairly from the teachings of Whitney and Cameron; and I also submit for your information the following quotation from Director A. D. Hall, of Rothamsted:

> "I cannot agree with Professor Whitney's reading of the results on the Agdell field in the least. The figures he quotes for wheat are hardly justifiable as approximations, and are in spirit contrary to the general tenor of the particular experiment...... In my opinion the results on the Agdell rotation field are directly contrary to Professor Whitney's idea that rotation can do the work of fertilizers." (From Report of the Committee of Seven, appointed by the Association of Official Agricultural Chemists "to consider in detail the questions raised", published in full in Circular 123 of the University of Illinois Agricultural Experiment Station.)

A thousand additional proofs of the practical value and of the evident necessity of supplying plant food in systems of permanent agriculture could easily be cited.

All long-continued investigations and, likewise, all practical agricultural experience show that great reduction in crop yields ultimately occurs unless plant food is restored to the soil; and, as a rule, the chemical composition of normal soil is an exceedingly valuable guide in determining the kind of material which should be supplied in practical systems of soil enrichment and preservation.

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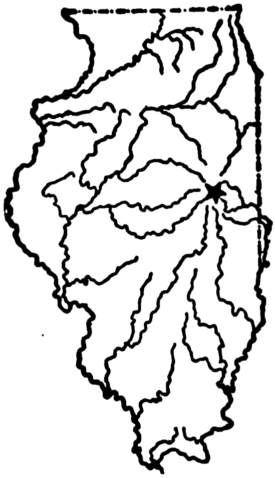
BULLETIN NO. 156

INSECTS INJURIOUS TO STORED GRAINS AND THEIR GROUND PRODUCTS

BY A. A. GIRAULT
ASSISTANT TO STATE ENTOMOLOGIST



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CONTENTS OF BULLETIN NO. 156

PAGE
Granary Moths 69
    The Angoumois Grain Moth (*Sitotroga cerealella Ol.*) 69
    The Mediterranean Flour-moth (*Ephestia kuehniella* Zell.) 72
    The Indian Meal Moth (*Plodia interpunctella* Hübn.) 75
    The Meal Snout-moth (*Pyralis farinalis* Linn.) 76a
Granary Beetles and Weevils 77
    The Confused Flour-beetle (*Tribolium confusum* Duv.) 77
    The Saw-toothed Grain-beetle (*Silvanus surinamensis* Linn.) 79
    The Granary Weevil (*Calandra granaria* Linn.) 80
    The Rice-weevil (*Calandra oryza* Linn.) 81
    The Yellow Meal-worm (*Tenebrio molitor* Linn.) 82
Measures of Prevention and Remedy 83
    Treatment of Infested Grain 84
        Fumigation with Hydrocyanic Acid Gas 85
        Fumigation with Carbon Bisulfid 87
        The Use of Cold and Heat 89
    Contact Insecticides 89
A Key for the Identification of Granary Insects 90

INSECTS INJURIOUS TO STORED GRAINS AND THEIR GROUND PRODUCTS

By A. A. GIRAULT, ASSISTANT TO STATE ENTOMOLOGIST

It is well known that many kinds of insects live in wheat and other grains and in meal and flour, either accompanying the grain to the granary from the field, or going to it after it is stored. Many, indeed, go with it from the producer to the customer—thru cribs, elevators, mills, and warehouses, to the retail store, and thence to our homes. Insects of these habits are particularly hardy, and many are so far omnivorous that they may live and multiply on food which seems to us to contain no nourishment. All are either beetles or their larvæ, or the larvæ of moths. The latter are of fewer kinds but of greater capacity for mischief than the former. At any particular time and place, half a dozen to a dozen of these insects may be present, working in various ways, some of them, indeed, not directly injurious but feeding on chaff or other granary debris, and obnoxious merely by their presence. Of the others, one or more may be injuring individual kernels of grain in a way to make them unfit for food and to prevent their growing if sown; or one may be webbing together flour and meal in mills, making them useless for food, and also clogging some parts of the machinery by webbing together masses of flour. Further harm may be done by causing fermentation in the stored grain. The percentage of actual injury may not be large for the whole mass infested, but the mere presence of considerable numbers of these insects reduces the value of the grain or flour, and may interfere seriously with its sale.

Over fifty species live habitually or occasionally in stored cereals and cereal products in the United States, but only about ten of these are of the first importance. Seventeen are habitual grain eaters, but the food of the others is comparatively miscellaneous, including granary rubbish, decomposing substances, cloth materials, and dried animal matter. Those which are regarded as of prime importance are the Angoumois grain moth, the Mediterranean flour-moth, the Indian meal moth, the meal snout-moth, the confused flour-beetle, the granary weevil, the rice-weevil, the saw-toothed grain-weevil, and the yellow meal-worm. Of the eight remaining habitual grain eaters, about two thirds are closely related to one or more of the preceding, but specifically distinct and less numerous.

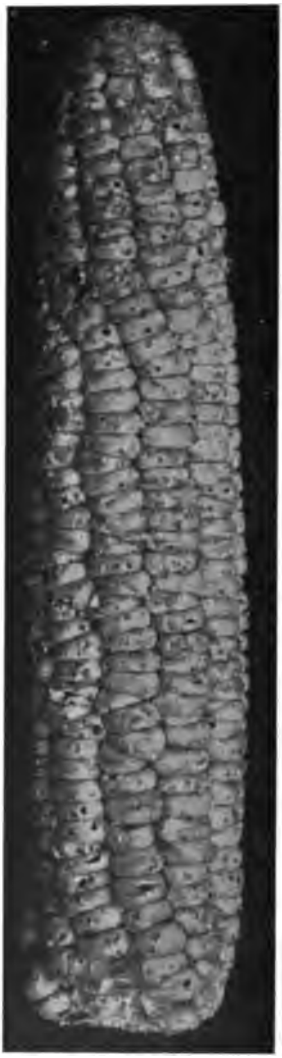

Fig. 1. Ear of corn injured by Angoumois Grain Moth, *Sitotroga cerealella.*

Among the forty species which are classed as miscellaneous in their food habits, some, such as the carpet-beetles, are usually household insects, and others infest museums, while a large number simply enter the granary, not merely because it contains grain, but for shelter and for other food, including such substances as the dirt in the cracks of the floors, bits of broken grain, dead insects, insect castings, molds, cobwebs, and cloth; or they may feed occasionally on grain alone. Many of these insects are introduced species, of cosmopolitan range, and are scattered abroad in shipments of stored grain and other products.

GRANARY MOTHS

THE ANGOUMOIS GRAIN MOTH

(*Sitotroga cerealella* Ol.)

A characteristic example of the work of this insect is an ear of corn peppered with small round holes, often two or three to a single kernel (Fig. 1). These are produced by a caterpillar which has eaten out the embryo and the other soft parts of the seed and has then cut through the top of the grain a small round hole which it has covered with a web. In the cavity within the kernel it changes to the moth, and then, breaking thru the delicate silk cover closing its burrow, it makes its way to freedom and takes flight.

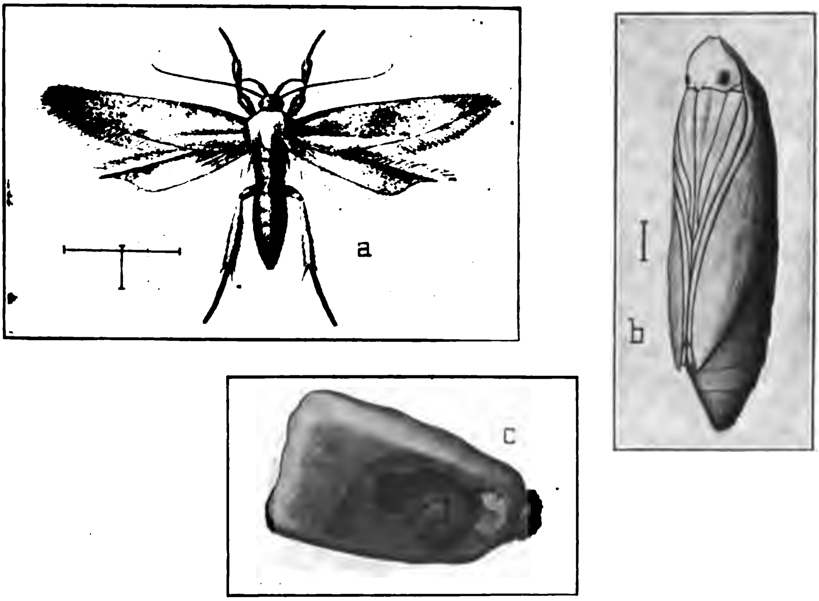

Fig. 2. Angoumois Grain Moth, *Sitotroga cerealella*: *a*, imago (×5); *b*, pupa (× 13); *c*, grain of corn with a portion of surface removed to show injury (× 3½).

DESCRIPTION

This insect belongs to the *Lepidoptera,* or family of moths, the young of which are called caterpillars. This species is commonly known to grain men as the fly-weevil—a very inappropriate name because it is not in any sense a fly.

The eggs laid by the female on the kernel are at first milky white, but soon turn to a pale reddish. They are elongate, slightly bottle-shaped, about a fortieth of an inch long, with a roughened surface which, when magnified, is seen to be marked with minute rectangles in regular rows, giving them a resemblance to ears of corn.

The recently hatched caterpillar eats its way into the lower end of the grain, making a barely visible round hole, which is the less noticeable because it is covered over with silk. The caterpillar begins to feed at once on the starchy material surrounding the embryo, and destroys the latter by the time it has itself become full-grown. (Fig. 2, *c.*) It is then about a fifth of an inch long, whitish, with a brownish head. A more complete description follows.

When first hatched the larva is no thicker than a hair, but when full-grown it is rather robust and gradually tapers backwards from the second segment. The head is brown, its lateral margins and the ocellar region are light, and the anterior margin is a little darker. The mandibles are strong, brown, bisetose, quadridentate, the lower tooth the larger and the size of the others gradually diminishing upward. The other mouth-parts and the antennæ are brown, the latter short, three-jointed, and ending in a bristle. The six ocelli are white, and arranged in the form of an elongate letter C, with the inclosed space varying from very dark brown to nearly black. On the head, body, and legs are sparsely-placed white, setaceous hairs, those on the head, the first and last segments, and the legs, rather long. On segments two to twelve inclusive these hairs are less prominent, and are arranged in two transverse rows, those of the anterior row much the shorter. On the first and thirteenth segments the hairs of the two rows are of equal length. The body is white, smooth, and densely covered with minute, erect spinules. In some examples traces of brown patches appear on the back of the first segment. The spiracles, dorsal hooks, and minute terminal hooks on the prolegs are brown. The legs are large at the base, but taper rapidly, each ending in a small hook. The ten prolegs are small and wartlike, and each end in two or three minute, robust hooks.

The pupa (Fig. 2, *b*) is about a fifth of an inch long, brownish, pointed ovate, with the adult appendages outlined thru the crust along its under surface. The wing-pads nearly reach the tip of the abdomen. The head end is obtuse; the posterior end more acute, and surrounded by a ring of sparse setæ. The head, thorax, and wing-pads are dark, the abdomen lighter brown. Eyes in mature pupæ black, and distinctly visible. On the abdomen are several rows of setæ, as follows: a double row on the side, above the spiracles, placed in pairs; a single row just below the spiracles and close to them; another double row on each side of the middle line of the body, the outer hair of each pair being on the posterior part, and the inner one on the anterior part of the segment. There are two long, slender, conspicuous bristles on the segment immediately behind the head.

The adult (Fig. 2, *a*), familiar to most elevator men, is a delicately built, small moth, with a quick wavering flight, which may be seen in infested rooms resting on bags of grain, walls, windows, or the like. It is about three eighths of an inch long, and grayish clay-yellow when at rest, but with hind wings dark grayish or neutral gray, and bordered with close, exceedingly delicate, silvery fringes. Each fore wing bears a black dot between its base and its middle.

LIFE HISTORY

When bred indoors the generations of this insect become confused, all stages being represented at once; but in the field there are two generations, which become adult in May or June and in August respectively. Where ear corn is infested in the crib the eggs are placed in the groove of the kernel on the ear, usually beneath the membrane which ensheathes the tip of each kernel. Wheat may become infested by the second brood of moths either thru eggs laid in the field on the grain in the head or else after storage in the granary, and a generation may develop from these eggs within five or six weeks. If an infestation begins in the field and the infested grain is carried to the granary, the moths come to maturity and continue to breed in the stored grain as long as the weather will permit; and the same is true, of course, if the grain is first infested after it has been stored. If the temperature of the storehouse is kept up by artificial heat, as in some warehouses, development may be continued thruout the winter; otherwise the female may deposit from sixty to ninety eggs, which hatch, as a rule, in from four to ten days, according to temperature.

DISTRIBUTION, INJURIES, AND ENEMIES

This moth, first noticed in France, is widely distributed in the United States and Europe. In this country it is most abundant in the southern states and where artificial heat promotes its multiplication in the northern granary.

Wheat may be as badly infested by this moth as corn, the heart of each grain being eaten out. Other cereals are injured less commonly, and cow-peas are sometimes infested by it. While the caterpillar is still young, infested kernels can not be distinguished except, perhaps, by their light weight. Later, however, a visible hole is made in the grain after the caterpillar is full-grown.

The larvæ of this species are infested by at least one parasite, and also by a minute, predaceous mite *(Pediculoides ventricosus* Newp.). This latter sometimes breeds in infested grain to an extent to become enormously abundant. By its infinitesimal bites it irritates the human skin, causing a rashlike and sometimes rather severe eruption, very annoying to harvest hands, grain-house employees, and others having to do with the handling of grain.

This grain moth may be most readily destroyed by fumigation with carbon bisulfid as described on another page.

THE MEDITERRANEAN FLOUR-MOTH

(Ephestia kuehniella Zell.*)*

When wheat flour in mills is webbed together in more or less irregular, matted masses (Fig. 3), very likely to cause trouble by clogging the mill machinery, the presence of the Mediterranean flour-moth is to be inferred. The adult of this insect is a small moth or miller, harmless in that stage, however, and injurious only as a larva. Its caterpillars make tubes of silk in which they live, covering them with flour upon which they feed. When full-grown they discard this tube and wander about in search of suitable places in which to pupate, spinning silk as they crawl, thus webbing the flour together. Preparatory to pupation a cocoon is also spun of silk matted with flour, which adds to the nuisance created by their presence.

DESCRIPTION

The egg of this insect is a little more than a sixtieth of an inch in length, elongate-oval, white and almost smooth when freshly deposited, but later becoming roughened and darker.

The caterpillar (Fig. 4, *a, d, e*) is about a half to three fifths of an inch long, when full-grown, and varies from whitish to pinkish in general color. The surface is sprinkled with short whitish hairs rising from minute but prominent tubercles.

The pupa (Fig. 4, *b*) is cylindrical, tapering posteriorly, with a cluster of small hooklets at the tip of the abdomen. It is reddish brown above, the head and thorax the darkest, and much lighter below, approaching a yellowish tint on the wing-pads and abdomen. The tip of the last segment is considerably darker than the rest of the body. The cocoon (Fig. 5) varies in length from two fifths of an inch to half an inch, and is about a fourth of an inch in width. It is composed of delicate silk, often intermingled with

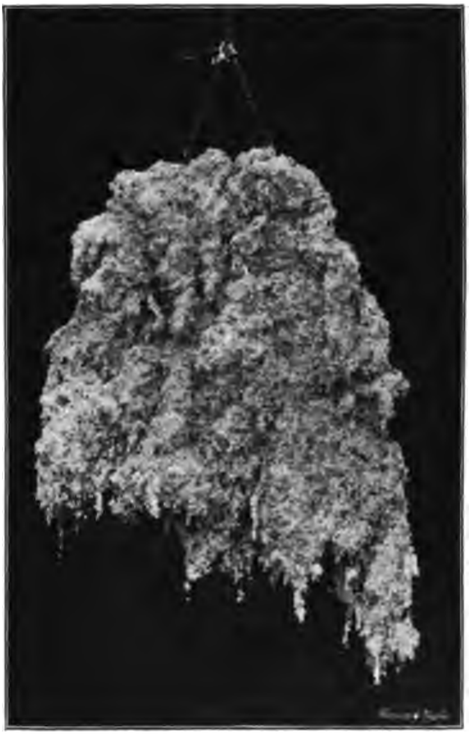

Fig. 3. Mass of flour held together by larval webbing of Mediterranean Flour-moth, *Ephestia kuehniella*.

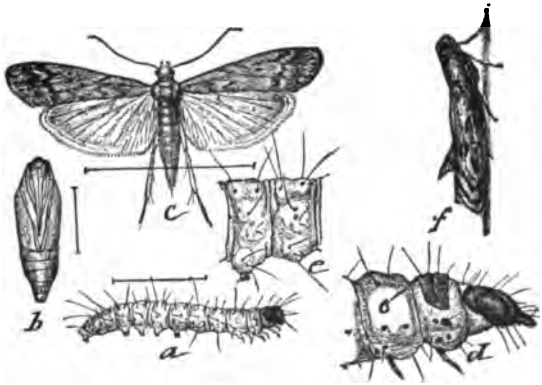

Fig. 4. Mediterranean Flour-moth, *Ephestia kuehniella: a,* larva; *b,* pupa; *c,* adult; *d,* fore part of larva; *e,* middle segments of larva; *f,* adult in resting position. Enlarged as indicated. (U. S. Dept. of Agriculture.)

particles of meal, flour, dirt, or other material. The pupa yields the adult in about two weeks.

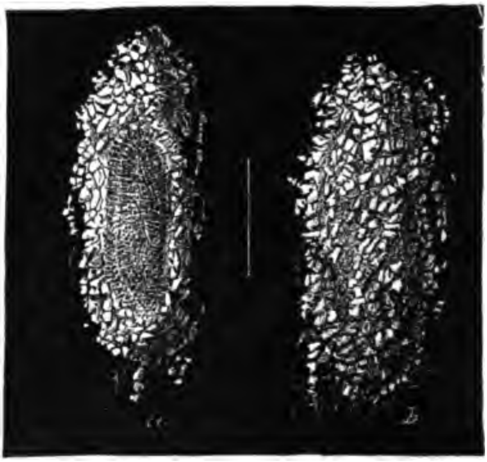

Fig. 5. Mediterranean Flour-moth, *Ephestia kuehniella: a,* cocoon from attached side, showing pupa thru thin silk wall; *b,* outer side of same.

The adult moth (Fig. 4, *c, f*) is about half an inch in length, and about seven eighths of an inch from tip to tip across the expanded wings. The front wings are medium gray, sprinkled with blackish scales and specks, and with a V- or W-shaped black line crossing about a third of the distance from the base. The hind wings are silvery whitish, with a darker border. Both pairs of wings are heavily fringed.

LIFE HISTORY, HABITS, AND INJURIES

This insect breeds thruout the year when the temperature permits. The female may deposit as many as two hundred eggs, which are placed singly in flour, in cracks of the floor, and in various places about the machinery of the mill. These eggs hatch in a little more than a week, on an average, the period being of course lengthened if the weather is cool. The caterpillars may get their growth in about forty days, and the pupa yields the adult in about eleven days. Approximately eight weeks are thus necessary to the development of a generation, with a variation of a week or more in one direction or the other according to the temperature. The adults live a little over a week. They have been known to fly at least six or seven rods from the place of emergence. They are active at night, but are not attracted to lights.

Altho wheat flour is most commonly infested, the larvæ of this moth are found also in rice flour, buckwheat flour, crackers, cotton-seed, corn-meal, oatmeal, rolled wheat, and other prepared cereals. They sometimes live, it is said, in the nests of bumblebees, and in the hives of the honey-bee.

The Mediterranean flour-moth is common and widely distributed on both sides of the world. It was first detected in Illinois in 1894.

The economic importance of this insect is shown by a statement made by Dr. F. H. Chittenden, of the United States Department of Agriculture, in a recent circular of the Bureau of Entomology on this pest (No. 112, issued March 7, 1910), in which he says that "this flour moth is attracting more attention than any insect that ever infested mills or other buildings where cereals are stored; indeed, it is almost the sole topic of complaint of millers at the present writing, correspondence in regard to weevils and flour beetles, which was at one time heavy, having fallen off very noticeably. * * *

"As to the losses caused directly and indirectly by this insect, it has been difficult," he adds, "to obtain estimates, the lowest being between $100 and $200 to a mill of 1,000 barrels capacity. The average loss due to closing down the mill and cost of treatment seems to be not far from $500 for each fumigation, 'to say nothing of the loss to business,' according to one Kansas milling firm. An estimate of $1,000 for two fumigations can not be far from right." * * * Thus, cleanliness in and about the mill, and care in examining returned bags and other materials entering it, will go far towards preventing or diminishing trouble from this moth.

TREATMENT

Where a mill is already infested, all flour or other mill products containing the insect should be promptly burned, and all spouts, elevator legs, other parts of machinery and other equipment, as also the walls, ceiling, and especially the corners in every part of the building, should be thoroly cleaned. Such thoro cleaning must be followed by fumigation with hydrocyanic acid gas, or by the use of artificial heat, both of which operations are described farther on in this paper under the head of Measures of Prevention and Remedy.

THE INDIAN MEAL MOTH

(*Plodia interpunctella* Hübn.)

With habits somewhat like those of the Mediterranean flour-moth, but occurring usually on the grain itself or else in meal, the caterpillar of this insect does most of its injury by spinning silk over whatever food it chances to be feeding on. It may construct a silken tube to live in, or simply spin its web in every direction. Bags of grain may thus become completely covered with closely matted silk, which it is practically impossible to remove, so that the grain must be rebagged before shipment. The caterpillar also spins a cocoon in the midst of its food materials.

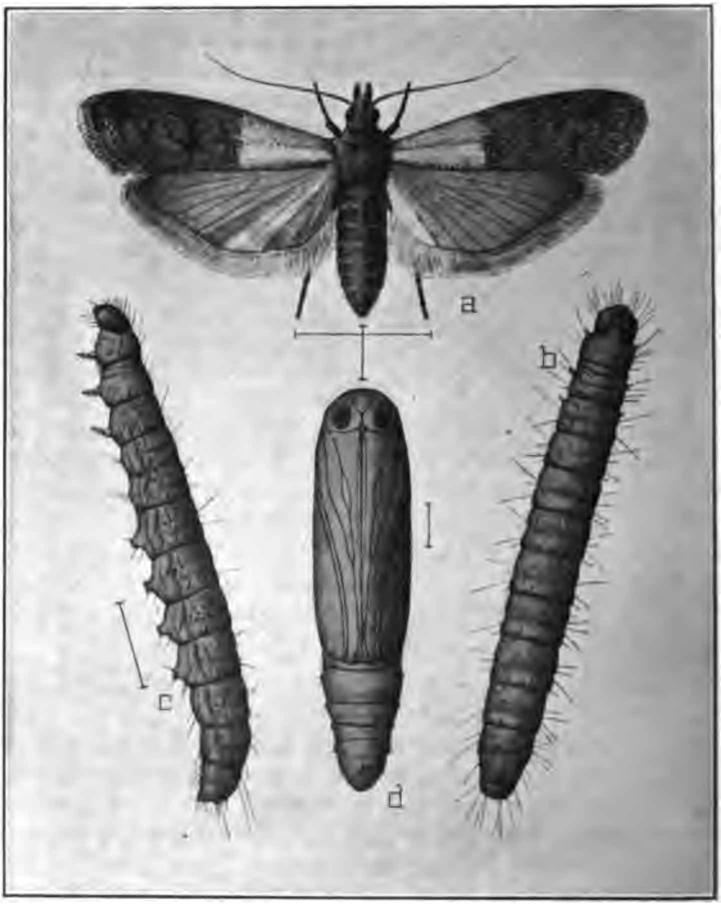

Fig. 6. Indian Meal Moth, *Plodia interpunctella*: *a*, adult moth; *b*, dorsal view of larva; *c*, side view of larva; *d*, pupa, ventral view. Enlarged as indicated.

The egg of the moth is whitish, and very small. The caterpillar (Fig. 6, *b*, *c*) is dull olive-greenish, varying to pinkish or whitish, and its elliptical, cylindrical cocoon is olive-green varying to light brown. The moths (Fig. 6, *a*) are active creatures, the outer two thirds of their fore wings reddish brown and the center copper, while the inner or basal third is dirty grayish. They measure about five eighths of an inch across the expanded wings.

The generations of this insect are irregular, and vary in number according to the temperature. The female may lay as many as

(The text of this intercalated page should immediately precede the heading Granary Beetles and Weevils, on page 77.)

THE MEAL SNOUT-MOTH

(*Pyralis farinalis* Linn.)

Hidden away in whatever substance is infested by it, the caterpillar of this beautiful moth is seldom seen. Its habits are somewhat similar to those of the Mediterranean flour-moth in that it lives within a silken tube, but it is more indiscriminate in its food. Thus it may feed upon the chaff from shelled corn in preference to the corn itself. Its silken tube is finely made, and completely covered by attached particles of the food.

The adult, or moth, of this species is really a very beautiful insect. Its wings are delicately colored, the base and outer portions of the front wings are brownish, and the whole of the middle portion is dusky whitish. Two wavy whitish lines cross these wings separating the light middle section from the brownish basal and apical parts. The hind wings are dusky whitish, with two wavy whitish lines running thru them and with a few brownish spots of varying size near the hind margin. The eggs are laid in masses and are irregular in shape. The caterpillar is dirty grayish in appearance, darker at both ends, the head brownish red. The pupa is brownish red and is enveloped by a cocoon.

The life history of this insect is not well known, but there are probably at least four or five generations in a season. Under ordinary conditions a generation has been known to develop in eight weeks in spring, and a shorter period may be expected at higher temperatures.

Altho a general feeder, this insect seems nevertheless to prefer waste matter, in damp places—accumulations of straw, chaff, meal, or other waste products from the granary or mill, occurring in corners, outhouses, and the like. It has also been reported to feed on hay, straw, corn, clover, seeds, dried plants, the grains and their products, and vegetable garbage.

Again, thoro cleanliness in regard to accumulations of rubbish in corners and so on, is prophylactic against this insect, and usually all that is required when the premises become infested is cleaning up and burning the infested material. If this is not possible, one should fumigate with carbon bisulfid, or use artificial heat.

three hundred and fifty eggs, either one by one or in clusters of a dozen or more. These eggs may hatch in four days, under favorable temperature conditions, and a generation may mature in about five weeks.

The food of this species is not limited to grain, flour, or meal, but includes such materials as preserved and dried fruits, peas, beans, edible nut-meats, chocolate beans, spices, sugars, yeast cakes, and some kinds of dried roots and barks. When infesting grains, this caterpillar eats out the embryo, leaving the rest of the kernel. A single larva will destroy a dozen or more grains, according to its size, and when thus engaged it spins its silk over everything in its immediate vicinity.

The species is found everywhere in the United States.

Fumigation with carbon bisulfid or with hydrocyanic acid gas, or the use of artificial heat, are the standard measures for the destruction of this as of most other insect pests of the granary and the mill.

GRANARY BEETLES AND WEEVILS

The hard-bodied insects known as beetles and weevils differ from granary moths in having biting jaws and horny wing-covers inclosing the membranous lower wings. They pass thru the same stages of development as the moths, but in the young, active stage, tho similar to caterpillars, they may be commonly distinguished by the absence of abdominal legs. In the third, or pupal, stage, they are not protected by a cocoon, and are usually white, with the appendages free. Unlike the moths, the adult beetles and their larvæ usually occur together, feeding on the same substances.

THE CONFUSED FLOUR-BEETLE

(*Tribolium confusum* Duv.)

Any small, shining, reddish brown beetle, about an eighth of an inch long, crawling about in large numbers in flour, meal, or prepared cereals, is almost certainly this insect. It is a flattened, oval beetle with the head and upper parts of the thorax densely covered with minute punctures, and with the wing-covers ridged lengthwise and sparsely punctured between the ridges. Its very minute eggs are white. The wormlike larvæ are cylindrical, wiry, white tinged with yellowish, and about three sixteenths of an inch long. The pupa is white.

Altho this insect is extremely common, living on almost any kind of vegetable debris, its life history is imperfectly known. Its eggs are said to hatch within six days at most favorable temperatures, and the larvæ to reach their growth in twenty-four days and the pupa in six—making a period of about five weeks for the development of a generation from the egg. Four or five generations may occur in a year, on an average, the number being dependent, however, upon the temperature, since development continues as long as this is favorable. This beetle is commonly found in oatmeal, corn-meal, prepared wheat and flour, seeming to have a preference for these breakfast foods. It is by no means limited to such materials, however, but has been reported from such substances as ginger, peanuts, beans, peas, orris roots, cayenne pepper,

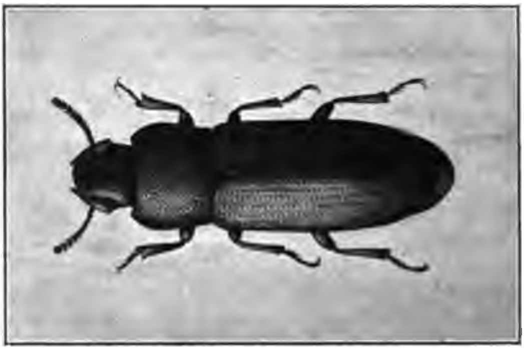

Fig. 7. Confused Flour-beetle, *Tribolium confusum*, adult. × 24.

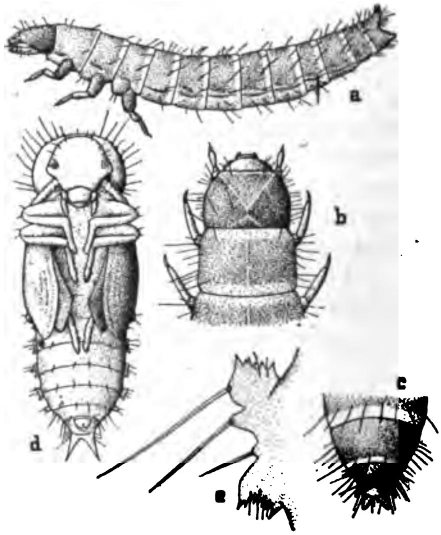

Fig. 8. Confused Flour-beetle, *Tribolium confusum*: *a*, larva (× 24); *b*, head of larva, greatly enlarged (dorsal view); *c*, anal end of larva, greatly enlarged (dorsal view); *d*, pupa (× 24); *e*, lateral appendage, greatly enlarged.

baking-powder, and snuff. Corn and wheat are also often infested by it, beetles and larvæ feeding upon the grains together, the former, in fact, being perhaps more destructive, and certainly more active, than the larvæ.

This species occurs all over the United States, and is cosmopolitan in its range.

Another beetle, called the rust-red flour-beetle (*Tribolium ferrugineum* Fabr.), less common than the preceding, is often found with it, being similar to it both in habits and in appearance. It is specifically different in the shape of the head and the terminal joints of the antennæ. It is also more southern in its distribution.

These insects may be killed in the grain by the use of heat, or by fumigation with insecticide vapors, as is elsewhere described; and all valueless infested material should be gathered up and burned.

The Saw-toothed Grain-beetle

(*Silvanus surinamensis* Linn.)

A minute, flattened, chocolate-brown beetle, with the margins of its thorax roughened with toothlike projections, if found abundant in groceries or other edible substances, may be assumed to be this grain-beetle. The slender adult is not more than a tenth of an inch long. The thorax is marked with two longitudinal grooves, one on each side, and with six minute teeth, like those of a saw, on each lateral edge. The head and thorax are densely covered with fine punctures, and the wing-covers are finely punctured and lined. The larva is somewhat flattened, with transverse, rectangular, yellowish spots above, margined with the white of the

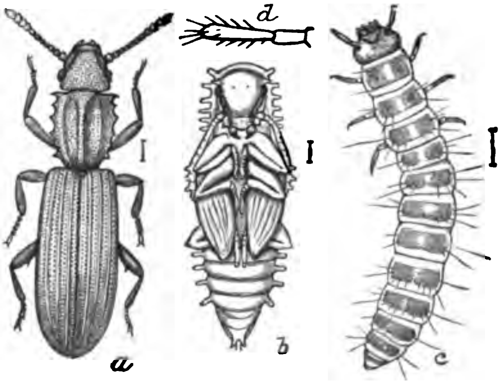

Fig. 9. Saw-toothed Grain-beetle, *Silvanus surinamensis: a*, adult; *b*, pupa, under side; *c*, larva. Enlarged as indicated. (U. S. Dept. of Agriculture.)

general body-color. On the thorax and anterior abdominal segments, a white line divides the rectangles into squares. The pupa is white, and is occasionally inclosed within a delicate cocoon composed largely of particles of the food substance. From five to seven generations of this species may be developed within a single year, the number depending, as usual, upon the temperature and upon the supply of food. The beetles infest almost anything of a vegetable nature used as human food, including preserved fruits and various cereals, bread, nuts, seeds, red pepper, yeast, spices, sugar, flour, and also tobacco and snuff.

This beetle is widely distributed, and virtually cosmopolitan in its range. At the Columbian Exposition in 1893 it was found in exhibits of food products from Brazil, Argentina, Paraguay, Trinidad, Mexico, Greece, Italy, Tunis, Liberia, and Java. It is generally distributed in North America.

THE GRANARY WEEVIL

(*Calandra granaria* Linn.)

Corn or wheat, the kernels of which contain a small, fat, legless, whitish grub, somewhat like those commonly found in nuts, but of much smaller size, is infested either with this insect or the closely related rice-weevil, next discussed. The beetle (Fig. 10) is about an eighth of an inch long, ovate, convex, and uniformly chestnut-brown, the thorax with elongate punctures in more or less definite lengthwise rows, and the wing-covers finely grooved and ridged lengthwise. The head is prolonged into a stout proboscis-like snout bearing the elbowed antennæ attached to its sides. The minute white egg is placed in a cavity made in a kernel of wheat or corn for the purpose. There is usually but a single grub to a grain of wheat, but there may be as many as two or three in a kernel of corn. As the beetles are unable to fly, they do not infest the ripened grain in the field. There may be four or five, or even more, successive generations in a year, each requiring about forty days for its development. As the adults

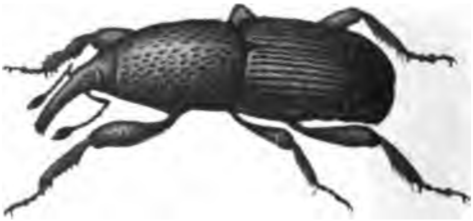

Fig. 10. Granary Weevil, *Calandra granaria*, adult. × 25.

may live six months or more if abundantly supplied with food, several generations commonly coexist in badly infested grain. Such grain is unfit for human consumption, and as it can not be separated from that which is uninjured, it is often a total loss.

Treatment by heat, and fumigation with carbon bisulfid, are the standard methods of destruction.

The species is widely distributed in the United States, but is more common southward.

THE RICE-WEEVIL

(*Calandra oryza* Linn.)

The beetle of this species (Fig. 11) differs from the granary weevil in being slightly smaller and of a duller brown, and by having on the wing-covers four more or less distinct reddish spots, two at the front angles and two near the tips. It is, moreover, able to fly. It varies in color, from light brown to black, and its thorax is densely covered with minute circular punctures not arranged in longitudinal lines. In its early stages it is so similar to the preceding species that a careful technical description is necessary to separate them.

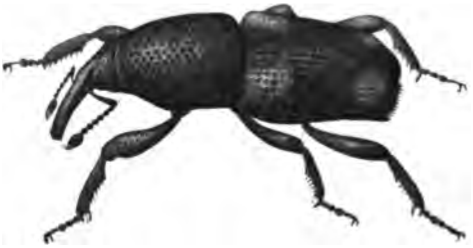

Fig. 11. The Rice-weevil, *Calandra oryza,* adult. × 25.

This beetle, having the power of flight, may infest the grain in the field even before this is fully ripe. A single female may produce as many as four hundred eggs, and altho the sexes frequently pair, reproduction sometimes occurs without this preliminary. The grub hatching from the egg is creamy white with a brownish head. The pupa is at first white, but turns to brownish as the beetle develops within. It is formed in a definite cavity or cell within an infested grain. Development may be greatly retarded, or even arrested, by cold weather, the insect living on in whatever stage it may have reached. A generation may develop in three to six weeks, according to temperature. The larvæ may reach full size in about sixteen days.

This weevil is especially troublesome southward, where it infests corn in the field and afterwards in the crib. The beetles begin to deposit their eggs in the South, early in June, and continue until the corn is ripe, adults emerging in about a month after the eggs are placed. This weevil may infest most of the cereals, and is especially common in rice. It has also been found in tobacco, in boxes of crackers and cakes, in macaroni, and other bread stuffs, and in barrels of flour and bags of meal. Its effect on ears of corn infested by it resembles closely that of the Angoumois grain moth, and as many as three or four may live and mature in a single kernel of that plant.

THE YELLOW MEAL-WORM

(*Tenebrio molitor* Linn.)

This is a cylindrical, yellowish, shining grub (Fig. 10, 11) about an inch long when full-grown, with the general appearance of a thick wireworm, often found in stored flour, meal, bran, and other similar material The adult belongs to the family known as darkling beetles (*Tenebrionidæ*), because they avoid the light. They do not infest crops, and are economically important only as they occur in stored products intended for consumption by man or beast. The beetle of this species (Fig. 12) is about five eighths of an inch long, somewhat flattened, with head and thorax minutely punctured, and with longitudinal raised lines on the wing-covers. The eggs are deposited singly or in small clusters in the food substance of the grubs. They may hatch in about two weeks. The young grub is white at first, but gradually turns to yellowish, darker at each end and also at the end of each segment. It may complete its growth in about three months. There is but a single generation in a year, the beetles emerging in April, May, and June. They are nocturnal in habit, flying about at night. The grubs commonly get their growth by fall or early winter, remain more or less active

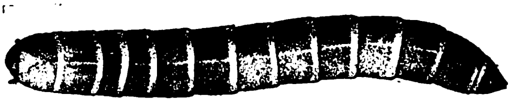

Fig. 10. Yellow Meal-worm, *Tenebrio molitor,* larva, seen from above.

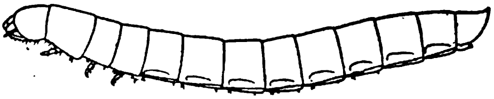

Fig. 11. Yellow Meal-worm, *Tenebrio molitor,* larva, side view.

during the winter season, and pupate in early spring, to emerge several weeks later in the beetle stage. The meal-worm feeds on flour, meal, and even the dust and refuse of mills and granaries. It has sometimes been found in ship's biscuit, and will doubtless infest similar cooked foods exposed to its invasion.

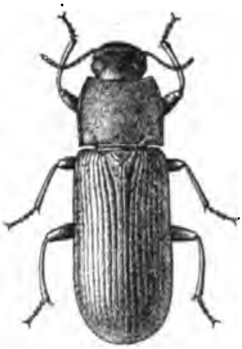

Fig. 12. Yellow Meal-worm, *Tenebrio molitor*, adult.

A closely related species known as the dark meal-worm (*Tenebrio obscurus* Linn.) is extremely similar to the foregoing, but dull pitchy black. In habits and economic relations this is a close parallel to the preceding, altho the larva has been taken in more unusual substances, such as cotton-seed, commercial soda, cotton-seed meal, black pepper, and commercial fertilizer. Both these species avoid the light, and are most likely to breed in dark unclean corners of mills and elevators. Thoro cleanliness is, consequently, an important preventive.

MEASURES OF PREVENTION AND REMEDY

Insects of the granary are much more easily kept out than put out. All places where grain or any of its products are stored should above all things be kept clean—not merely apparently clean, but actually so. Cracks in the walls and floor, for example, may seem to be clean when swept over, but may really be filled with the dust of grain and similar debris and thus become a breeding place for a number of granary insects. Storage rooms and bins should, in fact, be so constructed as to be free from cracks, the walls, floor, and ceiling smooth, and everything solid and snug. No rubbish of any kind should be allowed to accumulate, either in the building or on adjacent premises. Everything should also be done to keep insects out of the storehouse. Grain should be brought in from the field as soon as possible, since the longer it is exposed after ripening the more likely is to become infested by the Angoumois grain moth, the rice-weevil, and some other species. If found infested when brought in from the field, it should at once be fumigated with carbon bisulfid in a room especially constructed for the purpose in a manner to be described later. In the management of mills, returned bagging, second-hand machinery, and the like, should be carefully inspected or, better, regularly fumigated.

The more important special measures which, used alone or in combination, may prevent infestation by granary pests, may be described as follows.

1. Small grain should be threshed and stored as soon after ripening as possible. Wheat should be harvested and threshed directly from the shock if practicable, but if stacked, should not stand in the field longer than is absolutely necessary.

2. The place intended for the reception of a crop should be thoroly cleaned out some time in advance, and if there is reason to suppose that it has contained granary pests, it should be fumigated with sulphur. Complete protection against weevils requires that rooms for grain should be made tight, with windows screened and doors close-fitting, and also that they should be cool and dry. With proper care and some additional expense, any such structure can be made gas-tight and suitable for the fumigation of its contents with carbon bisulfid, but the need of thoro ventilation should not be left out of account.

3. If it were possible to dry grain from the field artificially at a temperature of 125° F. for four or five hours, all insects would be killed and the grain could then be stored in a thoroly clean and tight place, and safely left until needed for shipment or use. Corn which has been shelled dry and sacked is much safer than that left on the ear, whether with or without the husks. Grain stored for seed should be dried artificially, since it not only keeps better and germinates more generally, but it is also less liable to be eaten by such insects as devour the kernel.

4. Farmers, seedsmen, and millers should, in buying grain, make sure that it is free from insects.

TREATMENT OF INFESTED GRAIN

When a mill or storeroom full of grain has become infested with granary insects, an inspection should first be made as to the nature and extent of the infestation. Much time and money may often be saved in this way, for the trouble may prove to be of slight practical importance, and capable of being remedied by some simple and inexpensive operation. A seed-corn warehouse, for example, may be so generally infested by several insects that it would seem that serious damage must have been done, but it may be found that the more abundant of these insects are feeding on dust and rubbish derived from the grain, and that only one of them is actually injuring the kernels; and a thoro examination of fair samples may show that less than one percent of the kernels are actually injured. Corn in the ear may sometimes be sorted to advantage, if infested, with a view to removing ears showing injury and shelling and bagging the remainder. A general infestation may often be checked in its development by opening the warehouse in winter to lower the temperature, or by the use of heat as is presently to be described.

If, however, it appears that an infestation is general and the injury considerable, and that simple measures will not be sufficient, some more general program will be necessary. If fumigation with either carbon bisulfid or hydrocyanic acid gas is practicable under the conditions, this is by all means the most effective and satisfactory process in such cases; but this requires that it shall be possible to make the granary or storeroom virtually gas-tight, or so tight that the leakage of gas will be so slow that a fatal atmosphere may be maintained for a period of several hours.

Hydrocyanic acid gas is the more poisonous of these two substances, but the more difficult and dangerous of application, and as it has comparatively little penetrating power, it can not be used against insects infesting grain in bulk or against those which are inclosed within the kernel. It is the best fumigant, however, for use against the Mediterranean flour-moth, and for any other soft-bodied insects which do not penetrate deeply into the grain. Carbon bisulfid must be chosen if hydrocyanic acid gas is not available. Even where the storage rooms can not be made fit for the fumigation process, it may be possible to accomplish the purpose by constructing a special room or even erecting a small separate building thru which infested material may be passed in comparatively small lots.

Next to fumigation, extremes of temperature, especially sudden changes from one extreme to another, are on the whole, the most effective.

FUMIGATION WITH HYDROCYANIC ACID GAS

Preliminary to the fumigation of a mill, warehouse, or granary, the room or rooms to be fumigated should be thoroly cleaned and the sweepings burned. This operation is particularly important, as the gas to be used has little penetrating power, and living insects nesting away in a pile of rubbish, or hidden in a crevice packed with dirt, may escape uninjured. Next, everything must be done to make the place tight, windows and doors receiving special attention. Cracks around window-frames should be tightly stuffed with cotton batting, macerated paper, or white waste, or else thick soft paper should be fastened over the cracks with carpenters' glue or a good quality of flour paste. Broken or missing window-panes should, of course, be replaced. Keyholes in doors, and spaces between the door-frame and the door itself should be similarly closed. All outlets to the room—ventilators, registers, pipe openings, and the like, as well as cracks in the floors, ceilings, and walls—should be stuffed with waste and covered with paper. As carpenters' glue is difficult to remove, a good flour paste may be substituted for it where this is a matter of importance.

Hydrocyanic acid gas is produced by the reaction of cyanide of potassium, sulphuric acid, and water, the gas coming off with a more or less violent bubbling of the mingled fluids. The gas evolved is one of the most prompt and powerful poisons in common use, and the residue left after the reaction is sufficiently poisonous to make it necessary that it should be carefully disposed of by burying. The cyanide used should be in lumps, and 98 percent pure. To insure this strength a reliable brand should be bought in its original sealed package. That manufactured by Merck & Company, of New York, is of standard quality and can be depended on. Commercial sulphuric acid is of sufficient purity, but it should have a specific gravity of about 1.83 (66° Beaumé). Cyanide should be protected from moisture and kept in sealed vessels, as it is otherwise liable to decompose. Gloves should be worn while handling either of these chemicals.

To determine the amount of the ingredients needed for fumigation, one must first find the cubic contents of the containing room, making no allowances for furniture or other objects in it. An ounce, by weight, of cyanide, and a fluid ounce of commercial acid are needed for every hundred cubic feet of space in the room.

Three-gallon earthenware jars make suitable generators, and these should be provided at the rate of one for every five thousand cubic feet of space to be fumigated. As, for the best effect, the gas must be held at least eighteen hours, the importance of tight construction is manifest. If, however, this is impracticable, the strength of the gas—the amount, that is, of the ingredients per hundred cubic feet—must be increased according to the judgment of the operator. In some cases even twice the above quantities may be found necessary to a successful operation.

The containers should then be distributed thruout the room or rooms and the proper amount of water should be poured into each. The sulphuric acid should next be measured out and gently poured into the water. The cyanide of potash should be prepared for use by breaking it into lumps somewhat smaller than an egg. This should be done in the open air. It should then be carefully weighed out and placed in thin paper bags in quantity sufficient for each of the containers. One of these should be placed by the side of each jar, and then the sacks should be dropped carefully in quick succession into their corresponding jars in such an order that the operator shall not be exposed to the evolving vapors. When all is done the exit should be closed and locked, and a conspicuous label should be placed outside as a warning.

Fumigation should be done on a quiet day, as a high wind tends to blow the vapor thru such openings as may remain in the walls. A temperature of not less than 70° is to be preferred. Commonly two successive treatments three or four weeks apart are necessary to complete success.

The operator must bear in mind, in his plans and procedure, that everything must be done in such a way that he shall not breathe the escaping gas. Milk, meats, and other moist or liquid food materials, should be removed before fumigating, as they are liable to become poisoned by absorption of the gas. Arrangements should be made to open the building from without for ventilation when the fumigation is completed, and it should not be entered until it is practically free from the gas.

FUMIGATION WITH CARBON BISULFID

This volatile and exceedingly ill-smelling chemical has been more or less used against stored grain insects for many years, but recent experiments, including some of those upon which this discussion is based, have shown that the strengths at which it must be used and the best methods of its application, were but little understood, and that it has often been recommended for too many purposes and for use under really impossible conditions. This has resulted in many failures which have discredited it more or less as an insecticide for granary and warehouse use.

The commercial bisulfid is a heavy, oily fluid with a specific gravity of 1.29, boiling at 115° F., and igniting at about 300° F. It is cold to the touch, and because of its rapid evaporation it produces a freezing sensation when applied to the skin. When handled in quantity one's feet are likely to become cold, especially if any of the fluid is spilled upon the shoes. The vapor is a little over two and a half times heavier than air, a point to be remembered in application, since it goes first to the bottom of the inclosure. When mixed with air it becomes inflammable and explosive, especially when the mixture is in the ratio of about one part of the vapor to fourteen parts of air, equivalent to fifteen pounds of the fluid to a thousand cubic feet of space. Such a mixture of air and bisulfid vapor may be exploded by so small a cause as the spark made by hitting a nail or by turning an electric light on or off, instances of both of which have come within our own experience. The chemical leaves, on evaporation, a residue of impurities which stain cloth and other substances, so that direct contact with it should be avoided. Its rate of evaporation is in proportion to the temperature and the area of its surface of exposure, being very rapid when exposed in shallow vessels and at a high temperature. Its efficiency is also the greater the more rapid the evaporation and the higher the temperature. One volume of the liquid will produce about three hundred and seventy-five volumes of the vapor.

There is one effect of this gas upon the person handling it which should be especially borne in mind. When evaporated by spraying or sprinkling, or by exposing in many wide and shallow dishes, it accumulates very rapidly in the air, and unless one is careful it will soon affect him dangerously. Operators in large storage rooms applying the fumigant by means of a spray have become unconsciously intoxicated by it, and are liable to be overcome, with dangerous or even fatal consequences. The sense of smell becomes benumbed, hearing and sight are dulled, the action of the heart becomes quick and violent, and the mouth dry and parched. If these symptoms appear, the operator should at once abandon his task. A serious intoxication may last for several hours, accompanied by headache and followed by a taste of the bisulfid in the mouth for a day or two.

Altho carbon bisulfid was formerly supposed to be available only for grain in bulk, and not permissible for flour, it is now known that it may be used in mills without fear of injuring the flour in any way. The method of its use will vary somewhat according to the conditions present, but the fluid should be evaporated as rapidly as possible, and the vapor should be given off from as high a place as possible within the inclosure. A moderately high temperature is to be preferred, but is not indispensable. The best method of distributing the fluid is by means of an atomizer or a spray pump. If the latter is used, the liquid may be sprayed directly upon the ceiling; or it may be simply sprinkled over the exposed surface from a watering-pot.

When these methods are impracticable, it will accomplish the purpose if it is placed high up towards the ceiling in large, very shallow, dishes or pans, the sides not more than a quarter of an inch in height. Bags of cotton-seed or grain may be treated separately by means of an iron tube, provided with a conical tip, and pierced along its sides with holes to permit the escape of the liquid and vapor. In most cases, however, this individual treatment will be found unnecessary.

Our recent experiments, carried on with great care and duplicated many times, have convinced us that an effective fumigation requires ten pounds of carbon bisulfid to every thousand cubic feet of space to be treated. At this strength we have found the fumigant effective against all granary pests and at all temperatures. An effective treatment presupposes a construction of the granary or bin such as to hold the vapor for several hours without serious loss by leakage. It is at this point that most persons fail in practical work, since few storehouses or granaries are sufficiently tight to hold the vapor long enough, without special and careful preparation.

To protect one's grain or other property against insect pests he must either build his granary or storerooms in such a way as to permit effective fumigation, or he must provide a properly built room to be used especially for fumigation of infested materials. This room may, of course, be of any convenient shape, but it should not have more windows or doors than necessary, and it should not contain more than fifteen thousand cubic feet of space. The walls, ceiling, and floor should be similarly constructed—built, that is, of two layers of seasoned, grooved flooring of good quality, the outer layer running at right angles to the inner, and with glazed building paper between the two. Care must be taken with this layer of paper, as it is an important part of the structure. Wherever the edges are joined they should be broadly overlapped and secured by gluing. The door should be similarly constructed. The interior of the building should have all cracks, crevices, and holes closed by putty, after which it should receive a heavy coat of paint and should then be lined thruout with linen cloth stretched tight, lapped at the edges, and held in place by lathing. This cloth should be so placed that the laps do not come at the corners of the room, and it should be finally coated with moderately thick carpenters' glue, which substance has the great advantage that it is insoluble in carbon bisulfid. It must, however, be renewed if it cracks and scales off, as is sometimes the case, especially when the lumber is not well seasoned. The door should be treated like the walls. It should fit as tightly as possible, and clamps similar to those on refrigerator doors should be used to batten it.

THE USE OF COLD AND HEAT

It is a well-known fact that insects are peculiarly sensitive to sudden and extreme changes in temperature, and under storage conditions this susceptibility can often be made use of to excellent advantage. A zero temperature following upon one of 50° or 60° F., and quickly followed again by a temperature of 100° or more, will commonly kill every insect in an infested mill or storage room. Where steam heat can be applied, especially in northern Illinois, granary pests can thus be readily exterminated. Indeed, a temperature of 125° to 130° F. maintained for several hours by artificial means will itself destroy most insects; but for this it is necessary to provide steam radiators near the floor, to use direct steam under pressure, and to close down the mill or other building for about twenty-four hours.

CONTACT INSECTICIDES

In cleaning up infested places, cracks in the floor, walls, and ceiling must often be treated in a way to destroy the insects concealed within them. Gasoline and benzine are both excellent for this purpose, provided fire and lights be kept away from them until they have evaporated, as of course they presently do. They may be applied in any convenient way—by brushing, sprinkling, or spraying, according to the conditions present. They act at once upon contact, and if doors and windows are opened immediately after the application the vapors will soon disappear.

A KEY FOR THE IDENTIFICATION OF GRANARY INSECTS

This table is introduced to enable practical grain men and millers to identify insects found injuring stored grains and their products. It is simply a working table for the most important of these insects, and does not include, of course, all insects to be found in stored grain or in mills, some of which may be merely feeding on debris. The table is as free from technicalities as it is possible to make it. It should be remembered that all of these insects have four distinct stages of development, proceeding in succession from the egg to larva, pupa, and adult; also that all adult insects have six legs, neither more nor less, and that all here considered have two pairs of wings.

A. Moths or millers: the larva a caterpillar with distinct head, three pairs of thoracic legs and five pairs of abdominal legs, one of these pairs on the last segment. The larva usually spins a cocoon; the pupa is brownish, its appendages not free. The adult insects have two pairs of wings, the front pair longer and usually more colored than the lower or hind pair, which are usually grayish. Their bodies are soft, pliable, and covered with microscopic scales, like dust, and fine hairs. Insects of medium size, usually about half an inch long.

a. A small whitish caterpillar, living in grains of corn or wheat, eating out the embryo and other soft portions, pupating within the grain, and emerging thru a round hole at or near the tip of the kernel; this hole is covered with silk. Badly infested ears of corn look as if riddled with shot. Adult moths grayish clay-yellow, small...*The Angoumois Grain Moth.*

aa. Caterpillars which spin much silk, usually forming a silken tube to which they retire; this tube covered with particles of whatever substance they happen to be feeding upon. Living in flour, meal, or chaff, sometimes among grain, or in food substances such as prepared cereals. The full-grown caterpillars make a cocoon.

b. A free-living caterpillar usually not concealed within a silken tube, olive-green to pinkish in color, infesting grain or meal, webbing particles together, covering bags of grain with a web of silk, and generally scattering silk in all directions. The moth has the outer two-thirds of the fore wing reddish brown with the luster of copper, while the inner or basal third is soiled grayish; its hind wings are grayish. The cocoon is elliptical, slender, fragile, and of clear silk........*The Indian Meal Moth.*

bb. Caterpillars living in densely woven silken cases which are covered with particles of the food substance. Common in flour or chaff in corners.

c. A yellowish white to pinkish caterpillar living in flour, webbing it together and forming a cocoon covered with particles of flour. The moth is dark grayish, the fore wings silvery gray mottled with blackish streaks, one of which, obscurely resembling a letter V or W, crosses the wing between its base and middle; the hind wings are silvery whitish.........*The Mediterranean Flour-moth.*

cc. A soiled grayish caterpillar, darker at each end, living in chaff or other vegetable debris in dark damp places, securely webbing the food substance together so that it becomes matted; larval case and cocoon completely hidden, covered with the food substance. Adults very beautiful, base and outer portions of the front wings brownish red, the middle portion whitish, margined on each side by a thin wavy whitish line which crosses the wing and separates the three color divisions. The hind wings are whitish, with a whitish wavy line running thru them and a row of black spots around the hind margin....... ....*The Meal Snout-moth.*

AA. Beetles or weevils; the larva or grub with a distinct head, usually three pairs of thoracic legs but no abdominal legs, biting jaws. Does not spin a cocoon. The pupa is whitish, the appendages free. The adults are hard and horny, with two pairs of wings, the upper pair horny, closed together in a straight line over the back, and concealing the larger, folded, thin under pair. Their mouths are constructed for chewing; placed in weevils at the tip of a snoutlike prolongation of the head. Insects differing much in size; usually about as large as a grain of wheat, but varying up to a half-inch or more in length.

d. Small insects living in kernels of grain, or among grain and other stored products.

e. A very small, fat, humped-up grub, occurring in kernels of wheat or corn, like the grub in chestnuts but smaller, yellowish white, legless, very hump-backed and wrinkled, unable to crawl, its head inconspicuous and yellowish brown. The pupa is found within the kernel. The adult is smaller than a grain of wheat, with a snoutlike prolongation of the head, and elbowed feelers attached to the snout. Two brownish species, which feign death when disturbed. In ears of corn their work is very similar to that of the Angoumois grain moth, previously described.

f. The adult beetle is chestnut-brown, without spots on its upper wings. A slightly larger weevil than the next, more common in the North...*The Granary or Black Weevil.*

ff. The adult beetle is somewhat duller brown than the preceding with four reddish spots, one on each outer corner of the upper wing. A southern species.................................*The Rice or Spotted Weevil.*

ee. Small, more or less slender, somewhat flattened grubs, with distinct head and thoracic legs, crawling about in the debris of various grains or their products, or in vegetable foodstuffs. The adults are flattened, longer than wide, the head not prolonged into a snout. They occur with the grubs, actively feeding. Two distinct species and their allies; all small.

g. The grub uniform in color, whitish, about a quarter of an inch long, slender, its head narrower than the first body segment; pupa with the thorax not toothed laterally, but with most of the abdominal segments bearing a toothlike lobe, acute at each outer corner and toothed along its sides. The adult beetle is active, smooth, elliptical, and reddish brown. *The Confused Flour-beetle.*

gg. The grub whitish, with a rectangular yellowish area on each segment above, only the margin whitish as seen from above; the head broader than the first body segment. The pupa bears along each side of the thorax and abdomen a series of stout lobelike teeth, which are cylindrical-rectangular and blunt. The adult beetle is smaller than in the preceding species, color dark chocolate-brown, the sides of the thorax toothed like a saw.........................*The Saw-toothed Grain-beetle.*

dd. Large insects, living concealed in the bottoms of bins, corners, and the like, feeding upon flour, meal, or bran. The adults are large black beetles; the larvæ, large, cylindrical, wormlike creatures, resembling wireworms.

h. The adult not quite black in color, shining, its third antennal joint not quite twice as long as the second; larva light yellowish, shining....*The Yellow Meal-worm beetle.*

hh. The adult black and without luster, its third antennal joint thrice as long as the second; larva very dark, shining.........................*The Dark Meal-worm beetle.*

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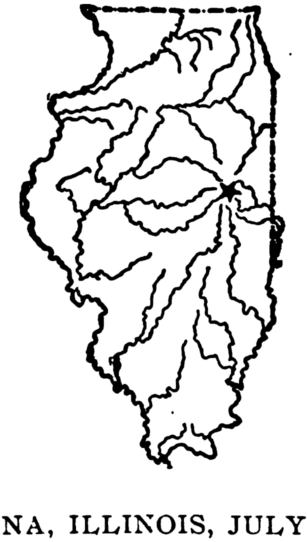
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN NO. 157

PEATY SWAMP LANDS; SAND AND "ALKALI" SOILS

BY CYRIL G. HOPKINS, J. E. READHIMER,
AND O. S. FISHER



URBANA, ILLINOIS, JULY, 1912

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The Station.

SUMMARY OF BULLETIN NO. 157

1. There are many thousand acres of peaty swamp land in northern Illinois, much of which produces almost no crops because the soil is deficient in the element potassium, altho it is rich in all other elements of plant food. Page 95.

2. On the University of Illinois soil experiment field near Tampico (Whiteside county), on peaty swamp soil, the addition of potassium produced yields of 41 to 55 bushels of corn as an average of the years 1902, 1903 and 1904, while, with no potassium applied, no ear corn was produced. Page 97.

3. On the University of Illinois soil experiment field near Momence (Kankakee county), on peaty swamp soil, potassium produced an average of 44.6 bushels of corn for 9 years, while without potassium the average yield was only 3.6 bushels. Page 100.

4. Some kinds of peaty swamp soil will improve with the right kind of cultivation, and finally become very productive soils which will not require the continued use of potassium, while other kinds will probably always require potassium to be applied. Page 121.

5. Some kinds of peaty swamp soils after years of cultivation are found to resemble sand ridge soil, which is most deficient in the element nitrogen, which can be obtained from the air at very slight cost by means of suitable leguminous crops. Page 122.

6. Nitrogen applied to the University of Illinois soil experiment field near Green Valley (Tazewell county), on sand ridge soil, has increased the value of six crops from $56.00 to $129.00 per acre. Page 123.

7. Certain kinds of farm manure produce fairly good results on some peaty swamp soils, but commonly it is better farm practice to use the manure on other kinds of soil and buy potassium for the peaty swamp soils. Page 128.

8. There is no more profit in starving plants than there is in starving animals. While heavy applications of potassium must sometimes be made at first, with proper management only light applications will be required after a few years. Page 129.

9. The so-called "alkali" soils of Illinois, which are also being investigated, are not the same as peaty swamp soils. Page 130.

PEATY SWAMP LANDS; SAND AND "ALKALI" SOILS

BY CYRIL G. HOPKINS, CHIEF IN AGRONOMY AND CHEMISTRY,
J. E. READHIMER, SUPERINTENDENT OF SOIL EXPERIMENT FIELDS, AND
O. S. FISHER, FIRST ASSISTANT IN SOIL FERTILITY

There are immense areas of peaty swamp lands in the northern and north-central parts of Illinois. As a rule these soils do not grow good crops. When first broken they sometimes yield one or two fair crops of corn, but generally the third crop is very poor, and afterwards little or no corn is produced. Oats do somewhat better, but usually the yield of grain is very unsatisfactory, even when a fair amount of straw is grown. These soils are usually very black and very rich in organic matter, and they are frequently drained at great expense with the expectation that they will be very productive and almost inexhaustible, but not infrequently they yield disappointment and financial loss.

These peaty swamp soils are present in large areas in Lee county, in southern Whiteside county, in Rock Island county, in the northeastern part of Henry county, and in the northwestern part of Bureau county. In Kankakee and Iroquois counties, in northern Mason county, and southwestern Tazewell county, large tracts of peaty soil are found; and smaller tracts are found in the counties of Winnebago, Boone, McHenry, Lake, DeKalb, and Kane, and there is more or less of this soil in several other northern counties, such as Kendall, Will, LaSalle, Grundy, Livingston, etc. Some peaty soil has been found in northern Ford county, and small tracts in western McLean and northern Champaign counties. This soil is also known to extend into northern Indiana,* southern Wisconsin,* and to a considerable extent into Iowa.

Of the counties in which considerable areas of peaty swamp soils are known to exist, Whiteside, Bureau, Kankakee, Tazewell, Lake, Winnebago, Kane, DuPage, and LaSalle have already been surveyed in detail. The survey has been started in Iroquois and Mason, and will be completed during the season of 1912. Boone, DeKalb, and Rock Island have been agreed upon and will probably be completed during the season of 1913.

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*The experiment stations of Indiana and Wisconsin have published some results of investigations relating to similar soils (See page 117.)

Commonly the peaty soil occupies the lower lying areas, but sometimes it is found in table lands. It is always on land which was at one time poorly drained.

The peaty soil varies from almost pure brown peat, containing 80 percent or more of combustible material, to black muck, containing much less organic matter. In some places these soils extend continuously over tracts of considerable size (sometimes over several square miles), to the exclusion of other types of soil; but more commonly the peaty soils occupy irregularly shaped areas scattered about in bodies of land of different kinds. Sandy land is frequently found adjoining or surrounding the tracts of peaty soil, and sand is the most common subsoil found under peaty swamp soils, altho a clay subsoil is found in places, and sometimes the peaty soil is underlain, at a depth of only a few feet, with limestone rock. Occasionally the peaty soil adjoins ordinary Illinois prairie land.

Peat itself consists largely of partially decayed sphagnum moss or coarse grass, swamp sedge, flags, etc., which grew in the water which once covered these areas. In growing, the moss, grasses, etc., obtain carbon and oxygen from the carbon dioxid in the air, and hydrogen from water, being similar to other plants in this respect. The water in which the sphagnum moss and grass grows is more or less stagnant. It is usually seepage or surface-drainage water, and contains sufficient nitrogen, phosphorus, potassium, and other essential elements of plant food to meet the needs of the growing vegetation. Both nitrogen and phosphorus enter into fairly stable organic combinations with carbon, hydrogen, and oxygen, and when the vegetation changes to peat, and even when the peat partially decays, these two elements (especially the nitrogen) are largely retained in the organic matter. The potassium, however, reverts more largely to the soluble form and it is finally lost to a greater or less extent in the drainage waters flowing from the peat bogs. Probably most of the Illinois beds are grass peat, altho there is some moss peat in the state. Indeed, in the detail soil survey of Lake county one swamp of several acres was found where the sphagnum moss is still growing luxuriantly over a bed of moss peat.

Where the soil consists very largely of decaying peat to a depth of 30 inches or more it is called deep peat (Soil Type No. 1401, Bulletin 123).

As shown in Bulletin 123, deep peat contains in one million pounds of surface soil about 35,000 pounds of nitrogen, 2000 pounds of phosphorus, and 2900 pounds of potassium. This shows in the surface 6⅔ inches of an acre about five times as much nitrogen as the rich black clay loam prairie. In phosphorus content these two soil types are about equal, but the peat contains less than one-tenth as much potassium as the black clay loam. Thus the total supply of potassium in the peat to a depth of 6⅔ inches (2930 pounds) would be equivalent to the potassium requirement (73 pounds) of a hundred-bushel crop of corn for only 40 years, or if the equivalent of only one-fourth of one percent of this is annually available, in accordance with the rough estimate suggested in Bulletin 123, about 7 pounds of potassium would be liberated annually, or sufficient for about 10 bushels of corn per acre.

A considerable number of the peaty swamp soils from different places in the state have been analyzed by the Experiment Station, and all of them are found to be very rich in nitrogen, well supplied with phosphorus, but very deficient in potassium, as compared with the ordinary fertile soils of the state.

Some preliminary field tests gave results strongly indicating the need of applying the available potassium to these soils. Pot-culture experiments gave similar indications, and the field experiments which are reported in this bulletin certainly furnish very conclusive proof of the power of potassium to increase the productive capacity of some of these soils.

TAMPICO SOIL EXPERIMENT FIELD

This, as one of the regular University of Illinois soil experiment fields, was located in the N. E. 40 of the S. W. ¼ of Section 6, Township 19 N., Range 7 E. of the 4th P. M., on the farm of Mr. J. H. Milligan, about five miles northeast of Tampico, Whiteside county, Illinois. The soil consists of black peaty material, rich in organic matter to a depth of sixteen inches. Between 16 and 30 inches the material is lighter in color and quite sandy, with little organic matter. The subsoil below 30 inches is almost pure coarse sand. This soil is fairly representative of considerable amounts of land in southern Whiteside and adjoining counties, which is non-productive, or of very low productive capacity, especially for corn.

This field consists of ten tenth-acre plots, numbered from 101 to 110. The individual plots are each two rods wide and eight rods long, each plot being surrounded by a cropped and cultivated border one-fourth rod wide, which makes one-half rod division strips between adjacent plots. The treatment applied to these different plots is what we call our "complete fertility test." It includes trials with applications of the elements nitrogen, phosphorus, and potassium, singly, in all possible double combinations, and all three together, all in connection with lime; also a double test as to the effect of applying lime, first with lime alone, and finally with the three elements added. The plan will be easily understood by reference to the tabular statements. (L means lime, N means nitrogen, P means phosphorus, and K means potassium, from the Latin name kalium, this symbol (K) being used for potassium by all nations.)

Nitrogen is applied in the form of dried blood, a material containing about 12½ percent of nitrogen. About 800 pounds of dried blood per acre are used each year. This would furnish about 100 pounds of nitrogen, or as much as is contained in 100 bushels of corn. Of course the nitrogen is purchased and applied in readily available commercial form in order to ascertain as quickly as possible if the soil is in need of nitrogen. If this were found to be the case it would simply indicate that in farm practice more nitrogen should be obtained from the air by means of leguminous crops, as we are doing in our rotation experiments (see Bulletins 123 and 125), and not that commercial nitrogen should be bought and applied to the soil (100 pounds of commercial nitrogen would cost about $15, while nitrogen can be obtained from the air with clover and other legumes, which are usually profitable crops to raise for their own sake.)

The phosphorus is applied in steamed bone meal. This materialcontains about 12½ percent of the element phosphorus in quite readily available form. About 200 pounds of steamed bone meal per acre are applied each year. This furnishes 25 pounds of phosphorus, or more than is contained in a 100-bushel crop of corn, the grain containing about 17 pounds and the stalks 6 pounds of that element. Owing to the fact that the steamed bone meal is not completely available the first season, the first annual application is usually 400 instead of 200 pounds (phosphorus in steamed bone meal usually costs from 10 to 12 cents a pound, the steamed bone meal itself being $25 to $30 a ton).

Potassium is applied in the form of potassium chlorid (containing about 42 percent of potassium), or potassium sulfate (also containing about 42 percent of that element). About 200 pounds of the salt are applied the first year, and 100 or 200 pounds per acre each year afterward. One hundred bushels of corn contain about 19 pounds of potassium in the grain and 2 pounds in the cobs, and the corresponding three tons of stalks contain about 52 pounds of that element. If the stalks or the ashes from the stalks are left on the land, well distributed, the annual loss in potassium is only about 20 pounds for a very large crop of corn, and 100 pounds of potassium chlorid will furnish 42 pounds of the element potassium. If both grain and stover are removed, about 200 pounds must be added each year.

The results obtained from the Tampico soil experiment field in 1902 to 1904 are shown in Table 1. It should be stated that altho lime was applied to certain plots in this field in the beginning of the experiment, in accordance with our regular plan of "complete fertility tests," it has produced no effect whatever, and the subsequent analysis of soil samples taken at the time the field was located also shows that the soil is not in need of lime. (Lime is added to supply calcium as an element of plant food, and also to correct any possible acidity of the soil, and thus to insure good physical conditions where the elements of plant food are added.)

TABLE 1.—CROP YIELDS IN SOIL EXPERIMENTS, TAMPICO FIELD, 1902 TO 1904

Soil plot No.	Soil treatment applied	Yield per acre				Value of 3 crops at 35c per bu.
		1902 Corn, bu.	1903 Corn, bu.	1904 Corn, bu.	Total yield for 3 years	
101	None..................	0	0	0	0	$ 0
102	Lime (and K after 2 years)	0	0	26 9*	26.9	9.41*
103	Lime, nitrogen..........	0	0	0	0	$ 0
104	Lime, phosphorus........	0	0	0	0	0
105	Lime, potassium.........	34.1	45.4	45.2	124.7	43.64
106	Lime, nitrogen, phosphorus.....	0	0	0	0	$ 0
107	Lime, nitrogen, potassium	37.6	58.7	44.1	140.4	49.14
108	Lime, phosphorus, potassium.........	35.3	46.8	43.0	125.1	43.78
109	Lime, nitrogen, phosphorus, potassium......	56.5	65.9	44.0	166.4	$58.24
110	Nitrogen, phosphorus, potassium.............	49.4	58.6	35.6†	143.6	50.26†

* 125 pounds potassium sulfate per acre was applied to Plot 102 in 1904.
† No potassium was applied to Plot 110 in 1904.

It will be observed that every plot to which potassium was applied produced a fair crop of corn, varying from 41 bushels to 55 bushels per acre as a three-year average, while not an ear of corn was produced on any plot not treated with potassium. Even the yield of stover, or barren stalks, was small on plots not receiving potassium. There was considerable variation in the yield of corn from the plots treated with potassium during 1902 and 1903. This was almost entirely due to the excessive rainfall and consequent injury to some plots from too much water. Like much of these swamp lands, this field was not sufficiently well drained to protect it in wet seasons. Plots 109 and 110, especially, and Plot 107, to some extent, were on slightly higher ground than the other plots, which is believed to account largely for the higher yields on those plots. In 1904, when the season was normal, no such differences occurred.

Plate 1 shows the corn growing on Plot 106 with nitrogen and phosphorus, on the left, and on Plot 105 with potassium, on the right.

The yields on Plots 5, 7, and 8 are probably considerably lower for 1902 and 1903 owing to the very wet seasons than they would otherwise have been. It is evident that the excessive amount of water in the soil retarded the nitrification of the organic nitrogen naturally contained in the soil in very large amounts; while the nitrogen supplied in the form of dried blood, being in the surface soil and very easily nitrified, did effect some increase in the yield wherever both potassium and nitrogen were added. This effect was plainly apparent during the growing season, the stronger growth and darker color of the plants treated with nitrogen in connection with potassium being distinctly discernible. Of course this result does not indicate that commercial nitrogen could be used with profit on this soil, but rather that the field needs better drainage in such wet seasons. This soil is naturally several times richer in nitrogen than the most fertile soils of the corn-belt. It is also well supplied with phosphorus. With more perfect drainage and a plentiful supply of potassium, this soil is undoubtedly capable of producing even more than 65 bushels of corn to the acre.

Plate 2 shows the 1903 crop growing on the Tampico field. The upper view shows Plot 5 (*potassium*) on the left, and Plot 6 (nitrogen and phosphorus) on the right. The lower view shows Plot 6 (nitrogen and phosphorus) on the left, and Plot 7 (nitrogen and *potassium*) on the right. (This soil naturally contains an abundance of lime, a small amount of which was added to these plots in the beginning of the experiment before the soil had been analyzed. The lime was not needed, however, and it has produced no effect.)

The experiments on the Tampico field were discontinued after 1904.

MOMENCE SOIL EXPERIMENT FIELD

This is also one of the regular University of Illinois soil experiment fields. It is located in the N. E. 40 of S. E. ¼ of Section 6, Township 30 N., Range 11 W. of 2nd P.M., on the farm of Mr. C. C. Porter, about three miles south of Momence, Kankakee

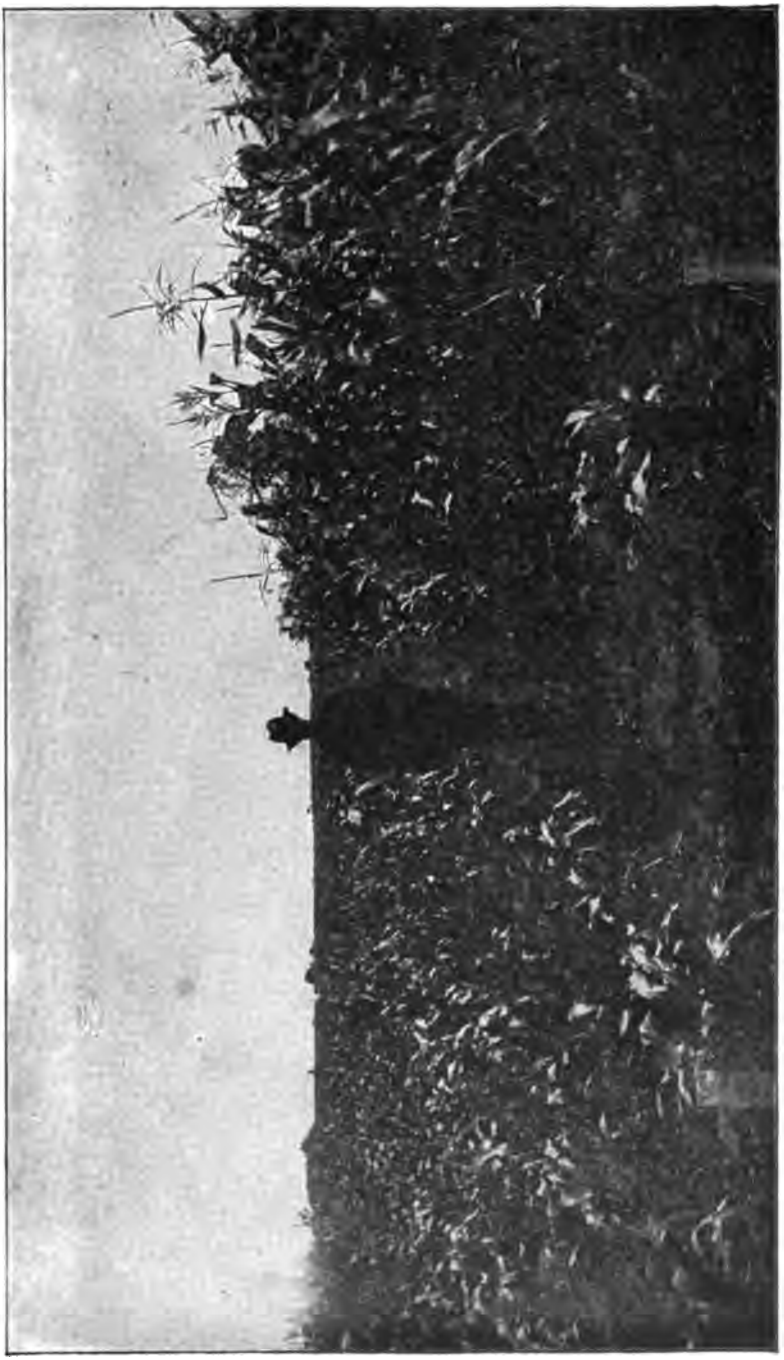

PLATE 1. CORN ON PEATY SWAMP LAND, TAMPICO FIELD, 1902. NITROGEN AND PHOSPHORUS ON LEFT, POTASSIUM ON RIGHT.

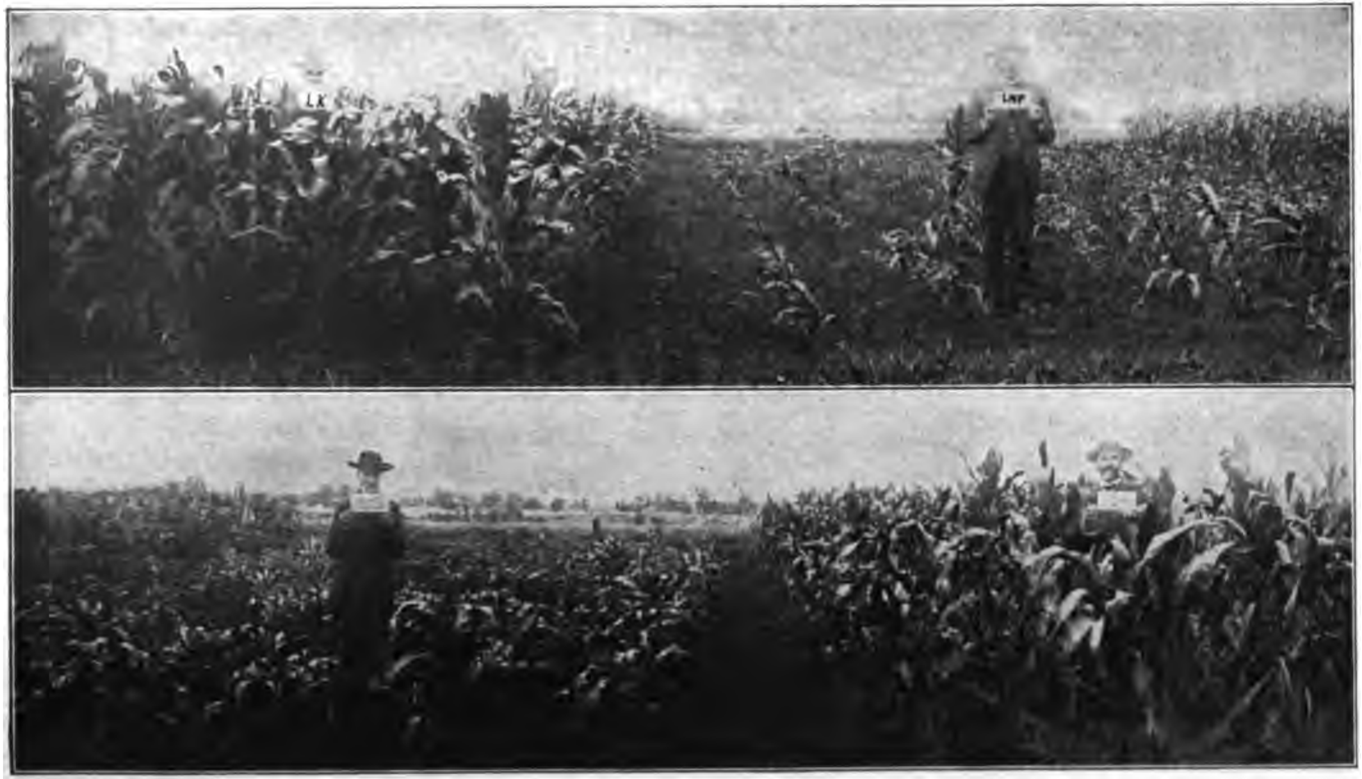

PLATE 2. CORN ON PEATY SWAMP LAND, TAMPICO FIELD, 1903. UPPER VIEW: POTASSIUM ON LEFT, WITH NITROGEN AND PHOSPHORUS ON RIGHT. LOWER VIEW: NITROGEN AND PHOSPHORUS ON LEFT, WITH NITROGEN AND POTASSIUM ON RIGHT.

county, Illinois, on peaty swamp soil which is underlain with impure limestone at a depth of two to three feet, with about 12 inches of yellow sandy subsoil between the black soil and the underlying rock.

A considerable part of the north half of Plots 101 and 102 and a smaller part of the other plots extend over somewhat different land where the soil contains sufficient available potassium to produce a medium crop of corn in a good season.* The south halves of the plots are on soil which is fairly representative of the most non-productive phase of this peaty swamp soil. There are very large areas of swamp soil in Kankakee and adjoining counties of very low productive capacity, much of which will respond to the same treatment as this field. (There are some probable exceptions, however, which will be noted below.)

Series 100 is laid out in the same manner and received the same kinds of treatment as the Tampico field. Table 2 shows the results which were obtained during a period of ten years (1902 to 1911).

During the ten years the field has been under the control of the University, nine corn crops and one oats crop have been grown. The average yield of corn on the four† plots receiving no potassium has amounted to but 3.6 bushels per acre, while the average yield of the four† plots treated with potassium, at the average rate of 154.3 pounds of potassium sulfate per acre per annum, has amounted to 44.6 bushels. The yields for 1902 are not as reliable as those for later years because the crop was considerably injured during that season on account of inadequate drainage, a condition which was corrected before the 1903 crop was grown on this field. Nevertheless the effect of potassium on the 1902 crop was very marked.

The total average value of the nine crops of corn (at 35 cents a bushel) on the four plots receiving no potassium amounted to $11.41, while the total average value of the nine crops of corn on the four plots receiving potassium amounted to $140.56, a difference of $129.15. The cost of the potassium at $50.00 per ton for potassium sulfate was $34.72. The average yearly increase on the nine corn crops due to potassium amounted to $10.49 per acre, or 372 percent on the investment.

Including the oats crop, which showed much less effect from potassium, the total average value of the ten crops from the four plots without potassium amounted to $16.03, while the total average value from the four plots receiving 154.3 pounds of potassium sulfate per acre per annum amounted to $147.17, a difference of $131.14. The average yearly increase on the ten crops due to potassium amounted to $9.25 per acre, or 340 percent on the investment.

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*In locating our soil experiment fields, we endeavor to select as uniform land as possible, but if there is any apparent difference in the field we always try to put the check plot with no treatment on the best soil in order that the effect of the treatment shall not be exaggerated.

†Plots 102 and 110 are not included in the averages.

Both nitrogen and phosphorus have produced some effect on the Momence field, especially during the later years. For the first four years nitrogen, as an average of two tests each year, showed an apparent loss of 2.3 bushels of corn per acre, but during the last five years there has been a gain of 5.3 bushels of corn per acre. During the first four years phosphorus made an average gain of 2.8 bushels of corn per acre, while during the last five years the gain has been 13.0 bushels of corn per acre, or a nine-year average gain of 8.5 bushels per acre. Phosphorus not only increased the yield sufficient to pay its cost when applied in the form of steamed bone meal at the rate of 200 pounds per acre per annum, but it also improved the quality of the corn by hastening its maturity. During the later years the increase has been sufficient to pay the cost of the treatment and to leave a clear gain of $2.05 per acre, or 82 percent net on the investment. With no provision for fresh, active vegetable matter, the phosphorus in the soil is less readily available than that applied in steamed bone, which contains some readily decomposable organic matter.

Plates 3, 4, and 5 show the crops growing on the Momence field in 1903. Plates 3 and 4 show Plots 1, 2, 3, 4, and 5, in the order given.

The upper view in Plate 3 shows Plot 1, to which no treatment was applied. On the right, looking over Plots 2, 3, and 4, we see Plot 5, to which potassium was applied.

The lower view in Plate 3 shows Plot 2, to which lime only was applied. On the right we see the good corn in Plot 5, beyond Plots 3 and 4.

The upper view in Plate 4 shows Plot 3, to which nitrogen was applied, on the right of which is Plot 4, with Plot 5 beyond.

The lower view of Plate 4 shows Plot 4 (phosphorus) on the left, and Plot 5 (*potassium*) on the right, where the corn yielded 72 bushels to the acre.

The upper view of Plate 5 shows Plot 5 (*potassium*) on the left, Plot 6 (nitrogen and phosphorus) in the middle, and Plot 7 (nitrogen and *potassium*) on the right. Potassium on Plot 5 made 72 bushels, and on Plot 7 potassium with nitrogen made 71 bushels of good sound corn (80 pounds per bushel), while Plot 6, between those two, made less than 4 bushels of nubbins.

The lower view in Plate 5 shows the effect of potassium on buckwheat on the Momence field, potassium having been applied on the right, and nothing applied on the left.

TABLE 2.—CROP YIELDS IN SOIL EXPERIMENTS, MOMENCE FIELD, 1902 TO 1911

Soil plot No.	Soil treatment applied	1902 Corn, bu.	1903 Corn, bu.	1904 Corn, bu.	1905 Corn, bu.	1906 Corn, bu.	1907 Corn, bu.	1908 Oats, bu.	1909 Corn, bu.	1910 Corn, bu.	1911 Corn, bu.	Value of 10 crops
101	None ...	6.9	14.9	4.8	6.8	6.8	.3	16.3	8.4	.3	9.2	$ 25.33
102	L	5.5	7.1	20.1*	33.9*	52.6*	14.9*	23.1	16.0	.9	15.2	65.10
103	LN	0	3.6	1.3	4.1	5.3	.4	15.6	3.8	1.1	8.2	14.41
104	LP	1.3	4.6	.4	1.8	1.9	.2	14.1	1.2	.1	7.0	10.71
105	LK	23.7	72.2	34.6	41.4	50.0	16.2	21.6	39.2	20.2	62.0	132.31
106	LNP ...	0	3.9	.6	1.6	4.5	.4	15.6	1.8	1.7	11.2	13.68
107	LNK ..	19.7	71.1	33.5	38.5	53.1	16.5	19.4	49.2	23.8	62.2	134.48
108	LPK	32.0	73.1	42.0	36.3	59.4	19.9	20.3	55.8	37.4	70.4	155.30
109	LNPK...	25.2	66.8	39.2	42.9	65.6	25.1	26.6	66.2	40.4	81.8	166.60
110	NPK ...	24.1	70.4	19.0†	24.8†	51.3	23.4	26.6	61.2	29.0	65.2	136.92

* Potassium sulfate was applied to Plot 102 in 1904, 1905, 1906 and 1907.

† No potassium was applied to Plot 110 in 1904 and 1905.

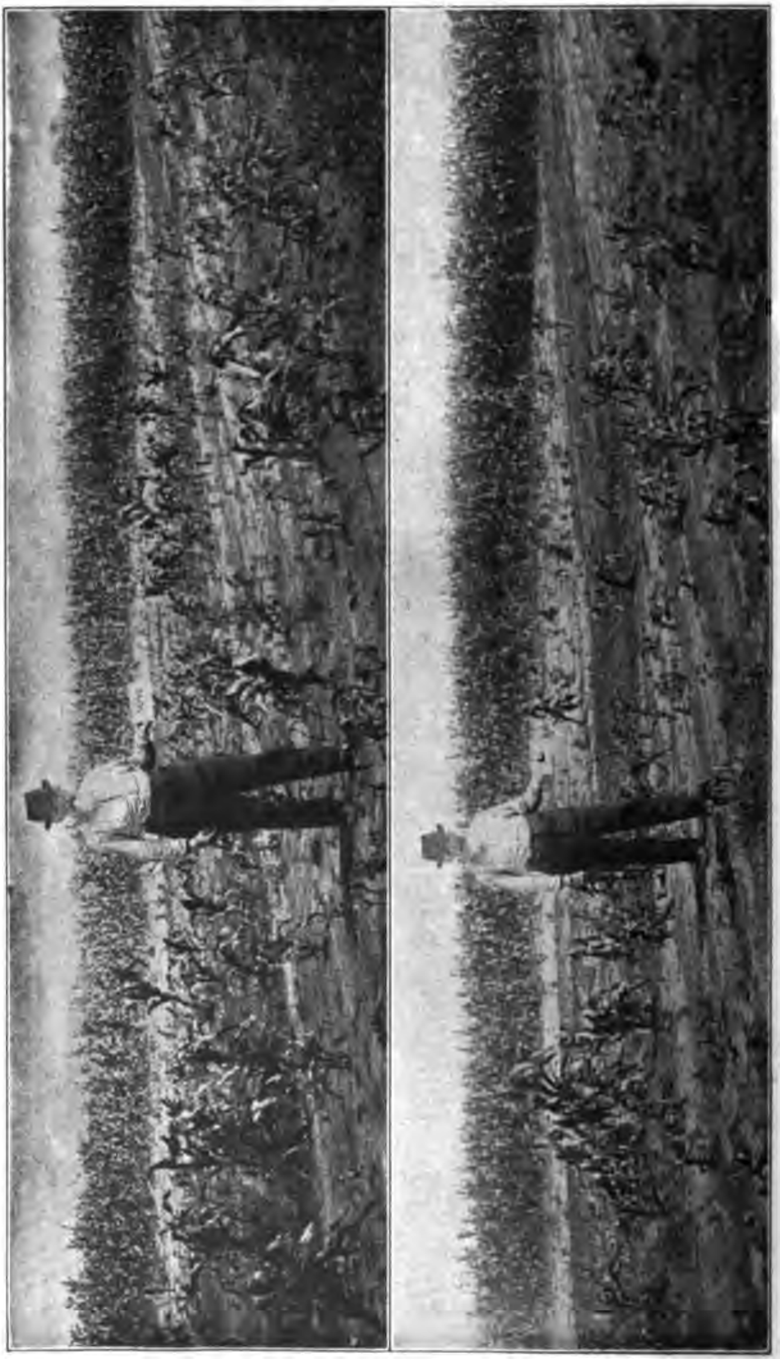

PLATE 3. CORN ON PEATY SWAMP LAND, MOMENCE FIELD, 1903. UPPER VIEW: NO TREATMENT. LOWER VIEW: LIME TREATMENT.

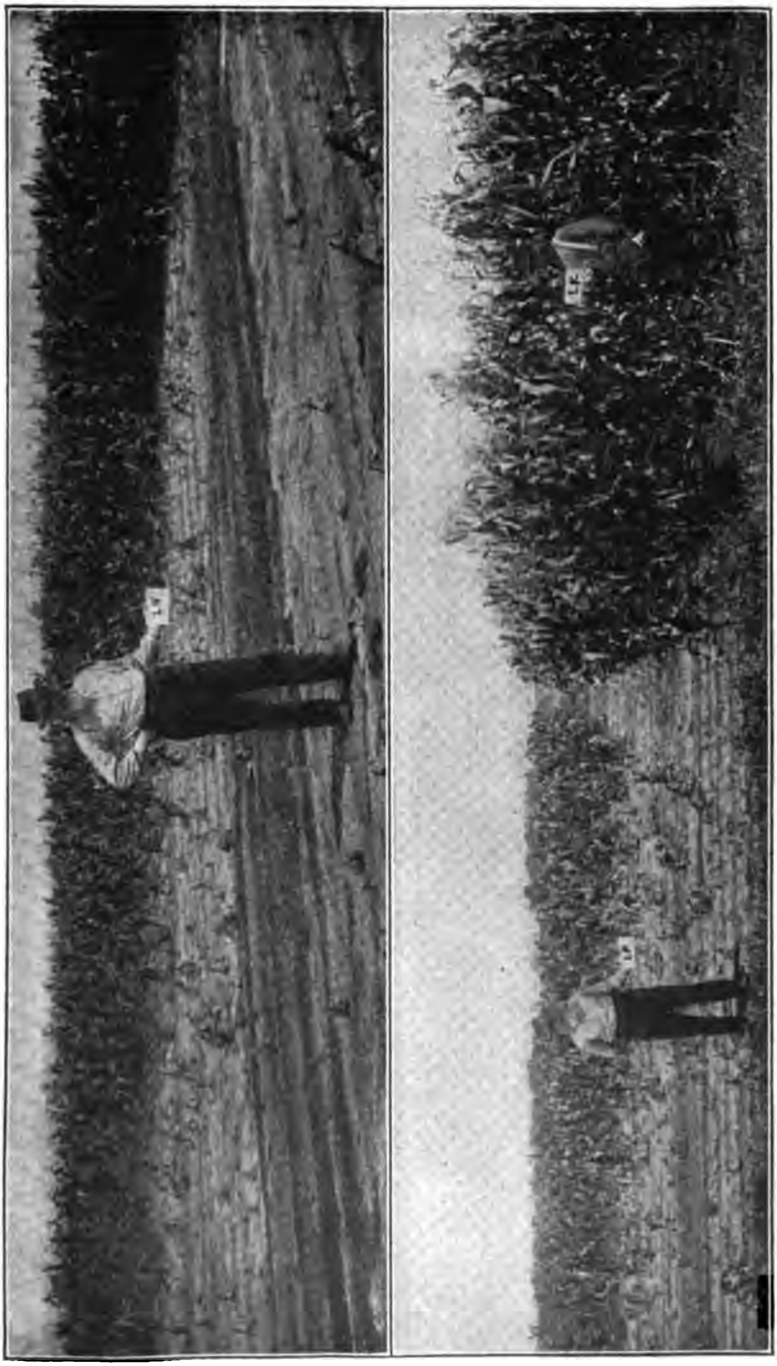

PLATE 4. CORN ON PEATY SWAMP LAND, MOMENCE FIELD, 1903. UPPER VIEW: NITROGEN. LOWER VIEW: PHOSPHORUS ON LEFT, POTASSIUM ON RIGHT.

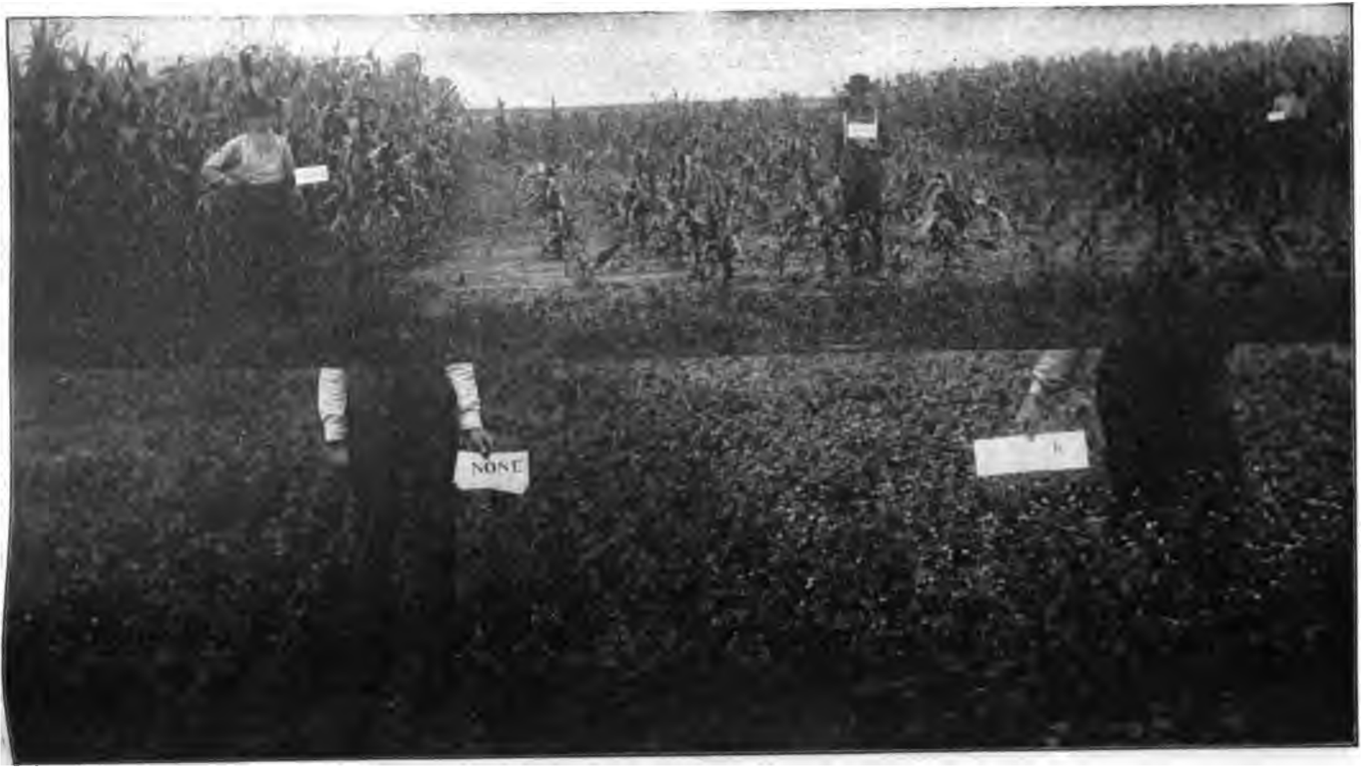

PLATE 5. CORN AND BUCKWHEAT ON PEATY SWAMP LAND, MOMENCE FIELD, 1903. EFFECT OF POTASSIUM. "SEE HIS FEET!" (APOLOGIES TO MESSRS. PORTER AND SONS.)

In Tables 3 and 4 are recorded the results from Series 200 and Series 300, Momence experiment field, 1904 to 1911.

The work was not begun on these series until 1904. A rotation consisting of two crops of corn, one of oats, and one of clover has been practiced. Instead of applying nitrogen in commercial form as on Series 100, the nitrogen has been provided for in legume crops, cover crops, and crop residues in the system of grain farming, and in farm manures in the live-stock system. The legume cover crops and crop residues have been made use of since the beginning, but no manure was applied till 1908 after the first clover crop of 1907. The manure was applied in proportion to the crop yields. Where larger crops were produced more manure was applied; and, of course, more manure was applied to Series 300 than to Series 200. The phosphorus was applied in the form of pure steamed bone meal, carrying 12½ percent phosphorus, at the rate of 200 pounds per acre per annum. No potassium has been applied to Series 200, but potassium has been applied to the whole of Series 300 at the rate of 150 pounds of potassium sulfate per acre per annum. Common salt (sodium chlorid) was applied to the north half of all the plots of Series 200 at the rate of 600 pounds per acre in the spring of 1908. So far as it is possible to observe, no effect has been produced by the salt.

The land on which Series 200 and Series 300 are located is naturally more productive than that on which Series 100 is located. The untreated land of Series 200 will produce under favorable conditions 10 to 15 bushels of corn per acre. The south half of Plot 202 occupies the area of an old stack bottom. For this reason the yields from this plot are too large for the first three or four years. The yields from Plots 201 and 203 were also influenced but not to the same extent.

As an average of sixteen tests extending over the last four crops, phosphorus has returned only $3.95 per acre in increased crop yields on Series 200, but $5.77 on Series 300. In neither case is the increase sufficient to pay for the phosphorus in 200 pounds of steamed bone meal per acre per annum, the amount applied to these fields. If finely ground raw rock phosphate had been used with the same effect, the increase would have paid the cost on Series 200 and more than paid the cost on Series 300. The manure paid in increased crop-yields $4.04 on Series 200, and $9.70 on Series 300.

On neither series was the increase more than sufficient to pay for the manure, which, as stated above, was applied in proportion to previous crop yields. The potassium produced an increase in eight years amounting to $42.98 per acre. The potassium cost in potassium sulfate, applied at the rate of 150 pounds per acre per

TABLE 3.—CROP YIELDS IN SOIL EXPERIMENTS, MOMENCE FIELD, 1904 TO 1911

Soil plot No.	Soil treatment applied	1904 Corn, bu.	1905 Corn, bu.	1906 Oats, bu.	1907 Clover, tons	1908† Corn, bu.	1909 Corn, bu.	1910 Oats, bu.	1911 Clover, tons	Value of last 4 crops	Value of unfertilized	Gain from treatment
201	None	14.2	11.4	29.4	0	9.2	19.0	36.9	.21	$22.20	$22.20	$ 0
202	Cover crop, crop residues	20.1*	16.1	32.2	0	8.2	25.2	37.5	Turned	22.94	22.90	.04
203	Manure	13.4	10.1	24.4	0	11.8	27.8	38.8	.23	26.88	23.60	3.28
204	Cover crop, manure	6.3	6.6	25.3	0	14.2	25.8	46.9	.44	30.71	24.30	6.41
205	None	4.4	5.6	21.2	0	8.2	17.0	48.1	.29	24.99	24.99	0
206	Phosphorus	8.7	8.6	23.4	0	14.0	16.0	51.3	.45	28.59	24.65	3.94
207	Cover crop, crop residues, phosphorus	10.9	10.1	30.6	0	6.0	17.6	42.8	Turned	21.10	24.31	—3.21
208	Manure, phosphorus	1.5	8.9	30.9	0	17.4	17.6	52.2	.80	32.71	23.97	8.74
209	Cover crop, manure, phosphorus	9.4	10.8	38.1	0	25.2	24.4	62.5	.58	39.59	23.63	15.96
210	None	6.5	10.0	29.4	0	8.6	14.4	45.0	.29	23.29	23.29	0

* An old stack bottom on south end of Plot 202.

† The system was not fully under way till 1908.

TABLE 4.—CROP YIELDS IN SOIL EXPERIMENTS, MOMENCE FIELD, 1904 TO 1911

Soil plot No.	Soil treatment applied	1904 Corn, bu.	1905 Corn, bu.	1906 Oats, bu.	1907 Clover, tons	1908† Corn, bu.	1909 Corn, bu.	1910 Oats, bu.	1911 Clover, tons	Value of last 4 crops	Value if fertilized only with potassium	Gain from treatment
301	Potassium	34.9	41.5	36.6	.10	20.2	44.4	35.6	.26	$34.85	$34.85	$ 0
302	Potassium, cover crop, crop residues	35.5	35.6*	38.1	.28	12.4*	54.0	38.8	Turned	34.88	36.94	—2.06
303	Potassium, manure	41.1	44.1	40.3	.30	20.0	58.4	39.1	.67	43.19	39.04	4.15
304	Potassium, cover crop, manure	38.5	40.5	33.1	.10	22.6	47.2	40.0	.59	39.97	41.13	—1.16
305	Potassium	42.9	45.2	41.2	.48	25.6	48.2	43.8	.71	43.23	43.23	0
306	Potassium, phosphorus	45.9	47.7	41.6	1.03	22.0	47.4	41.3	.98	42.56	41.27	1.29
307	Potassium, cover crop, crop residues, phosphorus	44.4	50.5	45.3	.40	15.8	53.6	40.0	Turned	36.29	39.30	—3.01
308	Potassium, manure, phosphorus	54.4	54.9	44.7	.33	29.6	59.4	53.1	1.13	53.86	37.33	16.53
309	Potassium, cover crop, manure, phosphorus	52.2	55.5	45.9	.05	23.8	54.2	51.6	.98	48.66	35.36	13.30
310	Potassium	30.3	37.5	35.3	.08	16.2	45.0	35.9	.20	33.39	33.39	0

* Damaged by standing water.

† The system was not fully under way till 1908.

annum, $30.00, leaving a net profit of $12.98 per acre, or 43.3 percent on the investment. Probably 100 pounds of potassium sulfate per acre per annum where used in connection with manure would have paid better than the heavier application.

During the last four years the potassium produced an increase in yield valued at only $13.79. This is barely sufficient to pay for the cost of the potassium.

OLD MANITO SOIL EXPERIMENT FIELD

This was a coöperative soil experiment field located on deep peat soil about one mile northeast of Manito, in Mason county, Illinois, almost on the line between Mason and Tazewell counties. It was on the farm of Mr. James Pollard, which was operated by Mr. Joseph Brenner.

The soil is a black peaty material, consisting largely of organic matter. It is quite uniform to a depth of several feet. At a depth of from six or eight to twelve or fifteen feet, the peaty material is underlain with sand.

In Table 5 are recorded all results obtained from the Old Manito experiment field, begun in 1902, and discontinued after 1905. The plots in this field were one acre* each in size, being two rods wide and 80 rods long. Untreated half-rod division strips were left between the plots, which, however, were cropped the same as the plots.

A large open ditch provides fairly good drainage for the swamp in which the Manito field is located, but the excessive rainfall of 1902 certainly injured the yield to a considerable extent. The fact that no further application of potassium was made for the second crop probably accounts for the comparatively low yield of 1903.

The effect of potassium on this field has been to increase the yield of corn from about 14 bushels to more than 40 bushels per acre. Phosphorus (in steamed bone meal) applied in addition to potassium (Plot 4) produced no increase over the potassium alone. The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of two tons per acre of ground limestone produced no increase in the corn crops, neither when applied alone nor in combination with kainit, neither the first year nor the second year.

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*In 1904 the yields were taken from quarter-acre plots because of severe insect injury on the other part of the field.

TABLE 5.—CORN YIELDS IN SOIL EXPERIMENTS, OLD MANITO FIELD, TYPICAL DEEP PEAT SOIL

Plot No.	Soil treatment for 1902	Corn 1902, bu.	Corn 1903, bu.	Soil treatment for 1904	Corn 1904, bu.	Corn 1905, bu.	Four crops, bu.
1	None..............	10.9	8.1	None..	17.0	12.0	48.0
2	None..............	10.4	10.4	Limestone, 4000 lb.	12.0	10.1	42.9
3	Kainit, 600 lb.....	30.4	32.4	Limestone, 4000 lb. Kainit, 1200 lb.	49.6	47.3	159.7
4	Kainit, 600 lb. Acidulated bone, 350 lb.	30.3	33.3	Kainit, 1200 lb. Steamed bone, 395 lb.	53.5	47.6	164.7
5	Potassium chlorid, 200 lb.	31.2	33.9	Potassium chlorid, 400 lb.	48.5	52.7	166.3
6	Sodium chlorid, 700 lb.	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lb.	13.3	14.5	Kainit, 1200 lb. ..	44.5	47.3	.....
8	Kainit, 600 lb	36.8	37.7	Kainit, 600 lb	44.0	46.0	164.5
9	Kainit, 300 lb......	26.4	25.1	Kainit, 300 lb.....	41.5	32.9	125.9
10	None	14.9*	14.9	None..............	26.0	13.6	69.4

*Estimated from 1903; no yield was taken in 1902 because of misunderstanding.

The results are practically the same whether the potassium is applied in the form of potassium chlorid, containing 42 percent of potassium, or as kainit, a crude mineral containing only 10 percent of potassium. Altho the application of 600 pounds of kainit is not quite equivalent to 200 pounds of potassium chlorid, the kainit has given nearly as good results during the four years' trials. The cost of 600 pounds of kainit is about the same as 200 pounds of potassium chlorid, unless the kainit were purchased in carload lots and the more expensive potassium chlorid in less than carload lots, a carload of kainit costing only about one-fourth as much as a carload of the chlorid or sulfate.

Of course it is somewhat more expensive to handle the heavier amounts of kainit, and the fact that 200 pounds of potassium chlorid contain 84 pounds of potassium, while the 600 pounds of kainit contain only 60 pounds of potassium, is evidence that the effect of the potassium chlorid will be no more lasting.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit furnished 60 pounds of potassium for the four years, or sufficient for 84 bushels of corn (grain and stalks). The difference between this and the 125.9 bushels obtained is 42 bushels, about what was obtained from the poorest untreated plot. It seems altogether probable that heavier applications of potassium (say 200 pounds of potassium chlorid each year) will increase the yield of corn on this soil to 60 to 70 bushels, or possibly more, as has been the result on the Momence field in the most favorable seasons.

The underdrainage provided for the Old Manito field was not sufficient for the best results, probably because of insufficient nitrification. In other experiments on peaty soil with imperfect drainage the addition of $15 worth of nitrogen with potassium produced about 15 bushels more corn than where potassium alone was used. (See Table 1.)

It should be borne in mind that the stalks for a hundred-bushel crop of corn require 52 pounds of potassium (besides that required for the root growth), while the 100 bushels of grain will require 19 pounds. Of course the stalks must be grown before the ears can be produced; and, while there is a strong natural tendency in corn, as in all plants, to reproduce seed, yet it has been shown by actual trial that in such soil as that on the Tampico field, for example, which, without treatment, is incapable of producing ear corn, small applications of potassium are practically useless, as they only effect a larger growth of stalks, but do not furnish sufficient potassium to enable those stalks to produce ears. This fact was well illustrated on Mr. Milligan's land adjoining the Tampico field in 1903. Because of the marked results produced by potassium on that field in 1902, Mr. Milligan used some potassium on his own corn for 1903. The amount of potassium chlorid which he purchased was not sufficient to make a heavy application to all of the land where he wished to apply it. He reduced the application to 50 pounds of potassium chlorid per acre on some of his land. As a result he obtained a largely increased growth of stalks, but still produced practically no ear corn. On such land, 200 pounds of potassium chlorid is worth very much more when applied to one acre than when scattered over four acres.

OTHER PEATY AND ALKALI SOILS

Aside from deep peat, there are many other types of peaty soil, as will be seen from the classification of Illinois soil types, (see appendix to Bulletin 123). Thus we find shallow peat and medium peat, underlain with clay, sand, rock, etc., and also sandy peat and peaty loam; and in some instances peaty soils also contain alkali, consisting chiefly of harmless calcium carbonate (limestone) with smaller amounts of injurious magnesium carbonate.

In some cases these peaty soils actually contain a good percentage of total potassium, more commonly in the subsurface or subsoil, but sometimes in the surface soil also, and yet the untreated soil is unproductive while the addition of potassium salts produces large and very profitable increases in the yield of corn, oats, etc.

In pot-culture experiments we have even been able by the addition of potassium sulfate to correct to a considerable extent the injurious property of magnesium carbonate that has been purposely applied to ordinary brown silt loam prairie soil which is known to contain abundance of available potassium.

These facts are mentioned here because we recommend, tentatively, the application of potassium salt to all classes of peaty and alkali soils that are unproductive after being well drained, whenever the supply of farm manure is insufficient. It should be understood that plenty of farm manure, preferably quick-acting, or readily decomposable, manure, such as horse manure, will supply potassium and thus accomplish everything that potassium salts can accomplish, and on some swamp soils manure produces good results where potassium is without effect.

In pot-culture experiments soils containing injurious amounts of magnesium carbonate have been treated with calcium sulfate (land plaster), which brings about a double decomposition, or interchange, forming the harmless insoluble calcium carbonate (limestone) and the very soluble magnesium sulfate, which is subsequently leached out, leaving the soil productive.

NEW MANITO SOIL EXPERIMENT FIELD

This is one of the regular University of Illinois soil experiment fields. It is located in the S. E. ¼ of N. W. ¼ of Section 19, Township 23 N., Range 5 W. of 3rd P. M., on the farm of W. N. Sunderland, about four miles east of Manito, Illinois, just across the line in Tazewell county, on alkali soil consisting of peaty, clayey sand with some gravel, and containing sufficient total potassium for normal crop yields.

A three-year rotation of corn, oats, and wheat is practiced on this field, and as there are three series, all crops are represented every year.

In Table 6 are recorded the treatments applied and the results obtained on the new Manito field for 1907 to 1911.

TABLE 6.—CROP YIELDS IN SOIL EXPERIMENTS ON PEATY ALKALI SOIL: NEW MANITO FIELD, 1907 TO 1911

Soil plot No.	Soil treatment applied	1907 Corn, bu.	1908 Corn, bu.	1909 Corn, bu.	1910 Corn, bu.	1911 Corn, bu.	Value of 5 Crops
1	None	8.8	34.9	8.6	8.0	20.6	$28.32
2W	Manure, 6 tons	43.5	29.1	35.7	67.5	35.2	79.51
2E	Manure, 12 tons	64.9	23.2	44.5	75.5		
3	Potassium sulfate	73.1	38.7	31.6	51.8	35.2	80.64
4	Calcium sulfate	5.0	13.4	2.1	4.8	15.7	14.35
5	None	5.4	10.3	4.6	14.6	18.8	18.80

Soil plot No.	Soil treatment applied	1907 Oats, bu.	1908 Oats, bu.	1909 Oats, bu.	1910 Oats, bu.	1911 Oats, bu.	Value of 5 crops
1	None	39.1	19.9	63.0	57.5	5.6	$55.53
2W	Manure, 6 tons	28.1	24.0	62.5	59.6	14.4	57.30
2E	Manure, 12 tons		23.8	67.5			
3	Potassium sulfate	41.9	20.3	62.6	68.8	15.6	62.76
4	Calcium sulfate	25.4	17.5	63.8	39.8	5.3	45.54
5	None	19.3	18.1	65.3	37.5	10.6	45.24

Soil plot No.	Soil treatment applied	1907*	1908 Wheat bu.	1909 Wheat bu.	1910 Wheat bu.	1911 Wheat bu.	Value of 4 crops
1	None		24.5	13.5	7.7	11.3	$39.90
2W	Manure, 6 tons		27.6	22.7	13.0	14.7	55.09
2E	Manure, 12 tons			24.1			
3	Potassium sulfate		27.8	18.3	22.0	16.0	58.87
4	Calcium sulfate		20.1	14.7	7.0	5.7	33.25
5	None		21.5	2.0	7.7	6.0	26.04

* The field was secured too late to seed wheat for 1907.

The manure is applied once during the rotation for the corn crop at the rate of 6 tons per acre to the west half of Plot 2 and at the rate of 12 tons per acre to the east half of Plot 2. The potassium has been applied at the rate of 148 pounds of potassium sulfate per acre per annum. For the first three years, 1907 to 1909, 400 pounds per acre were applied in 1907, but since then it has been applied every year. Plot 4 was divided into four equal parts and calcium sulfate (land plaster, gypsum) was applied at the rate of 2 tons, 4 tons, 8 tons, and 16 tons, per acre, at a cost of $6.00 per ton. None has been applied since 1907.

The calcium sulfate has produced no increase whatever. It was applied with the thought that by double decomposition and leaching the harmful magnesium might be removed. Thus far, however, it does not seem to have produced the desired result in these field experiments.

Both the manure and the potassium have produced good results. The soil on this field is not uniform, and, as has always been the practice, the check plots were given the advantage by being located on the better soil. This is readily seen by examining the yields, especially for Plot 1. As a result of this the increases recorded do not fully represent the total effect of the soil treatment.

The effect of the manure has been to increase the value of the corn crop for the five years by $55.95; of the five oats crops by $6.91; and of the four wheat crops by $22.12; or a total for all crops of $84.98, or $1.89 per ton of manure. In almost every instance where the yields were kept separate the heavier application of manure has produced the larger yield. The 6 tons of manure contained only about 60 pounds of potassium, which is not as much as the three crops removed. It is only about one-third as much as was provided in the potassium sulfate at the rate of 150 pounds per acre per annum. The 12 tons of manure per acre also did not supply as much potassium as is needed on this soil because when a larger amount was applied in the 150 pounds of potassium sulfate a still further increase in the yield resulted.

From the results of the first three years where 400 pounds of potassium sulfate per acre were applied for the rotation, it would seem that it is better to apply the potassium annually rather than in large amounts at long intervals.

The effect of the potassium has been to increase the value of the corn crop for the five years by $57.08; of the five oats crops by $12.37; and of the four wheat crops by $25.90; or a total for all crops of $95.35. As an average of the five years, the 150 pounds of potassium sulfate produced an increase in crop yields valued at $6.36 per acre, which gives a net profit of $2.60 per acre per annum. One hundred fifty pounds of potassium sulfate, costing $3.75, has produced as large an increase as 3 tons of good stable manure. This reduces the value of the manure to $1.25 per ton as compared with potassium sulfate for treating peaty alkali land.

RESULTS OF INVESTIGATIONS IN INDIANA AND WISCONSIN

As previously stated, the Indiana and Wisconsin experiment stations have reported some investigations of non-productive soils, including some peaty swamp soils.

Bulletin 57 of the Indiana Agricultural Experiment Station on "The Improvement of Unproductive Black Soils," by Professor H. A. Huston, published in 1895, contains the following general conclusions:

> "The use of straw or kainit has proved very profitable as a means of *temporary* improvement of such lands.
>
> "The *permanent* improvement of such lands must be effected by efficient drainage."

In the summary of Bulletin 95 of the Indiana Station, which was published in 1903, and which is essentially a reprint of Bulletin 57, Professor Huston inserts the following additional conclusion:

> "On black lands containing considerable sand but not having a high water level, kainit and other potash salts have proved very profitable fertilizers for corn."

The Indiana Agricultural Experiment Station has in press a new bulletin on "Unproductive Black Soils," giving the results of experimental work carried on during the last eight years. This bulletin corroborates the conclusions given in previous bulletins.

The Wisconsin Agricultural Experiment Station has published a number of bulletins on the drainage and treatment of the marsh lands of Wisconsin. Among the more recent publications are Bulletin 139, "Principles and Maintenance of Soil Fertility;" Bulletin 146, "Drainage Conditions of Wisconsin;" Bulletin 199, "The Principles and Practice of Land Drainage;" and Bulletin 205, "The Development of Marsh Soils." The authors of these bulletins in summing up their conclusions make the following statements:

> "The drainage of marshes is the first step toward improvement. On large marshes the organization of drainage districts and the co-operation of a number of adjoining landowners is necessary, but thousands of farms include some marsh land which can be readily drained by the owners without legal difficulties.
>
> "Proper tillage of marsh lands is of the utmost importance. Heavy rolling, by packing the loose peat soil, produces a firmer seed bed which is better adapted to cultivated crops, especially small grains.
>
> "Fertilization of marsh soils is important on account of the unbalanced condition of the elements which they contain. Marsh soils are excessively rich in nitrogen, but are frequently deficient in phosphorus and potash. While barnyard manure will supply the last two elements, these can be supplied in commercial fertilizers, allowing the use of barnyard manure on upland soils where its nitrogen as well as its mineral elements are needed. Under such special conditions it is profitable to use commercial fertilizers supplementing the manure of the farm.
>
> "Acidity develops in marsh soils quite commonly where lime carbonate is not brought in from surrounding higher land. This acidity, however, does not interfere with the growth of crops provided the soil is properly fertilized. Very commonly acid soils require phosphate fertilizers as well as potash. The acidity of marsh soils in the southeastern part of the state is very generally neutralized by the lime carbonate in the water seeping in from the surrounding higher lands of this limestone section.

"The crops best adapted to marsh lands include corn, potatoes, cabbage, buckwheat, and timothy and alsike clover for hay. When the soil is thoroughly firmed by rolling, small grains can be grown, of which wheat and barley are best, with oats and rye second. Excellent tame grass pastures can be developed on these marshes with proper care."

PLANT FOOD IN DIFFERENT SOILS*

It is true that plants are composed very largely of the elements carbon, hydrogen, and oxygen, that carbon and oxygen are obtained from the carbon dioxid in the air, and that hydrogen is one of the elements of which water is formed. It is also true that plants must be supplied with the elements sulfur and iron, but these two elements are required by plants in relatively small amounts, and practically all soils are abundantly supplied with them. The other five elements of plant food, nitrogen, phosphorus, potassium, calcium, and magnesium, are required by plants in very considerable amounts, and they may be present in soils in limited quantities.

Nitrogen is a constituent of organic matter. Consequently, if a soil is rich in organic matter (humus or vegetable matter), it is also rich in nitrogen; and if a soil is poor in organic matter, it is also poor in nitrogen. If more nitrogen is needed it can best be obtained by growing leguminous crops, provided with the proper nitrogen-gathering bacteria, which have power to obtain nitrogen from the air.

Phosphorus is also associated with organic matter to some extent, so that a soil very rich in organic matter (as peaty soils) is not only exceedingly rich in nitrogen, but it is usually well supplied with phosphorus. In the light-colored timber soils, and in worn prairie soils, phosphorus is more or less deficient in the soil. It can be supplied profitably in steamed bone meal, and more profitably in finely ground rock phosphate, but it should be used in connection with leguminous crops or farm manure.

Potassium is commonly associated with clay. It is contained in all ordinary Illinois soils, as the common prairie soils, in great abundance. Peaty soils not mixed with clay are, as a rule, very deficient in potassium. Sand soils also are usually poor in available potassium, altho the total supply may be quite large, but locked up in the sand grains. Sand soils are likewise commonly deficient in some other elements of plant food, especially in nitrogen.

Calcium is contained in all limestone, and dolomitic limestone, which is the abundant limestone of northern Illinois, contains both calcium and magnesium.

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*For more complete information regarding the different elements of plant food the reader is referred to Bulletin 123, "The Fertility in Illinois Soils," a copy of which will be sent upon request to anyone interested in Illinois agriculture.

With these facts in mind, it is possible for the farmer to estimate with some degree of accuracy what will be required to increase the productive capacity of the different kinds of peaty swamp soils, and whether the treatment must be continued indefinitely, year after year, or whether the soil is likely to improve after a few years.

GENERAL INFORMATION REGARDING PEATY SWAMP SOILS

Peaty swamp soils may well be separated arbitrarily into five fairly distinct classes:

1. Soils in which the very peaty material extends to a depth of three or four feet at least and often to much greater depths.
2. Soils with one to three feet of peaty material resting on deep sand.
3. Soils with one to three feet of peaty material resting on rock, usually with some inches of sandy material between the two.
4. Soils with six inches to three feet of peaty material resting on a clayey subsoil.
5. Soils with only a few inches of peaty material resting on sand.

If the soil has one to three feet of very peaty material and this is underlain with a deep sand subsoil or with sand resting on rock, or if the peaty soil itself is very deep (3 or 4 feet or more), then the land is almost certainly deficient in potassium, and the chief part of the potassium required to produce crops must always be supplied, either in the form of commercial potassium salts or in farm manure, because of the simple fact that it cannot be furnished by either the soil or subsoil in sufficient quantities for continuous large crops. As the one to three feet of peaty material is exceedingly rich in organic matter, and is much richer in nitrogen, and usually somewhat better supplied with phosphorus, than the most fertile normal soils in the corn belt, that land is not in need of either of those elements, and probably it will be unnecessary to grow clover or to apply phosphorus on such soils for many years. Indeed, it seems altogether likely that the most profitable system of farming for such soils is almost continuous corn, unless some rotation should become necessary because of corn insects. As farm manure contains about as much nitrogen as potassium, and also some phosphorus, it is better farm practice to use farm manure on sandy land, for example, which is usually somewhat deficient in available potassium, and very greatly in need of nitrogen and organic matter, than it is to use the manure on this peaty soil which needs only potassium. Ordinary farm manure contains about 8 pounds of potassium in a ton, and some of this is not very readily available, excepting in such kinds as horse manure which decompose quickly.

If one has abundance of farm manure, and does not need to use it all on lighter soils, of course it should be applied to the peaty soils rather than not be used at all; but under the ordinary farm conditions, where the supply of farm manure is very limited, it is good practice to purchase commercial potassium for such peaty lands as need it.

As stated above, there are some peaty soils which are underlain with clay subsoils lying from 6 inches to three feet below the surface. Such subsoils almost invariably contain an abundance of potassium. Some of these are the soils which will ultimately "farm out," to use a phrase local to the Kankakee swamp region, which means that with continued farming the soil gradually improves until it finally becomes a normally fertile soil, even without any special treatment. The time required for this improvement will depend upon the condition and method of management of the soil. The desired result is usually accomplished by getting some of the clayey subsoil mixed with the more peaty top soil. Sometimes this can be done by deeper plowing; sometimes by the tramping of live stock, where the subsoil is near the surface. Some soils of this class are temporarily benefited very markedly by even light applications of potassium, either in farm manure (preferably horse manure) or in commercial form. This will furnish sufficient potassium to give the corn a start, and the corn roots will thus be enabled to grow sufficiently to reach the clayey subsoil which will then furnish an abundance of potassium for a large crop. This may last for a year or two only, when it will be found necessary to supply more potassium to the top soil; or, the one or two years' cropping and cultivation may result in the compacting of the surface soil, the mixing of the clayey subsoil with the peaty top soil, or the bringing up of sufficient potassium from the subsoil into the top soil by the roots of corn and weeds and the corn-stalks (which, it should be remembered, are quite rich in potassium, and which are usually either burned or plowed under) so that no further application of potassium may be necessary. Thus, the so-called "farming out" process may be hastened very materially, and with decided profit on some soils, by applying potassium in some form, especially where the peaty top soil is too deep to admit of reaching the clayey subsoil with the plow.

In its original condition this type of peaty land (that is, a peaty top soil underlain with a clay subsoil) contains an abundance of all of the elements of plant food; but the difficulty is that the nitrogen is nearly all in the top soil, while the potassium is very largely in the subsoil (both soil and subsoil commonly contain enough phosphorus), and the chief problem with these particular soils is to bring these elements together in the top soil sufficient for the needs of the growing crop, especially during its earlier growth before its roots reach the lower stratum.

Very satisfactory results have been obtained upon this particular kind of soil, in Ford county, Illinois, simply by means of very deep plowing, as on Mr. S. K. Marston's farm in what is called "Vermilion Swamp," in northern Ford county. A careful examination was made by the Experiment Station of land in this swamp some years ago. The soil produced very poor crops of corn, but the clayey subsoil was found to be within the reach of the plow, and it was then agreed with Mr. Marston that a trial of deep plowing should be made, and the result has been very successful, as will be seen from the following extracts from a letter received from Mr. Marston:

"ONARGA, ILL., October 31, 1903.

"DR. C. G. HOPKINS,

"DEAR SIR:

"I went to my farm yesterday to ascertain the effect of the fertilizers that I had used. My tenant says he can see no perceptible effect. But I can say that deep plowing has done the business. I saw yesterday some of the finest, soundest, heaviest corn I ever saw, and the yield sixty bushels to the acre.

My tenant is a thorough convert to deep plowing. His plowing this year is nearly a foot deep. We have decided that the soil contains all necessary constituents. Deep plowing seems to be a great success.

"Respectfully,

"S. K. MARSTON."

There is still another kind of peaty swamp land which must be mentioned. This is land whose soil consists of only a few inches of peaty material, which is underlain by sand to a depth of several feet. We have found quite extensive areas of this type of soil, especially in the southeastern part of Kankakee county. The sandy subsoil will usually furnish somewhat more available potassium than the peaty material, and the sand, being near the surface, becomes mixed with the peaty material by plowing and cultivation, so that this soil may produce fair crops for a few years. But after the rather small amount of organic matter becomes reduced by cultivation, this type of soil is but little different from ordinary sand soil, which is usually very poor in nitrogen and rather low in all elements of plant food. If the sand contains some clay, which is quite frequently the case, it will be better supplied with potassium than with the other elements. As a rule it is deficient in available potassium, and after a few years of cropping it also becomes deficient in nitrogen.

It will be of interest and value even to farmers who may have such very sandy swamp soils to know of the results which have been obtained from our "complete fertility tests" on the sand ridge soil in Tazewell county, a type of soil which is more deficient in nitrogen.

GREEN VALLEY SOIL EXPERIMENT FIELD

This is one of the regular University of Illinois soil experiment fields. It is located in the S. W. 10 of N. W. 40, of N. W. ¼ of Section 3, Township 22 N., Range 5 W. of 3rd P. M., about two miles southwest of Green Valley, Tazewell county, Illinois, on the farm of Mr. J. C. Drake. The soil is typical of the cultivated sand ridge soil, and fairly represents very large areas of sandy land, not only in Tazewell and Mason counties, but also in Whiteside and adjoining counties, Kankakee and adjoining counties, and in smaller areas in many other parts of Illinois.

In composition this soil averages about 1400 pounds of nitrogen, 800 of phosphorus, and 31,000 pounds of potassium in the surface 6⅔ inches (2½ million pounds). The high percentage of potassium shows that this soil is not a pure quartz sand, but is to a considerable extent of granitic origin. In composition this soil is extremely poor in nitrogen, rich in potassium, and fairly well supplied with phosphorus, if we consider its very porous character and the very deep feeding range afforded to plant roots.

This field was broken out of pasture in 1902. In Table 7 are reported all results secured in the six years 1902 to 1907 from that part of the Green Valley field where the nitrogen as well as the other elements were supplied in commercial form. (This experimental field was conducted on leased land and this work was discontinued after six years.)

Plots 1 (especially) and 2 in this series were naturally more productive than the other plots, it being the regular custom of the Experiment Station to use the most productive land for the untreated check plots if any such differences are apparent when the field is established, as was the case in this instance. Plot 1 serves only as a check against the lime treatment, and the average of Plots 2, 4, 5, and 8 gives a more reliable basis of comparison for ascertaining the effect of nitrogen.

A four-year rotation of corn, corn, oats, and wheat was practiced on this part of the Green Valley field, and at the end of six years we are at the middle of the second rotation.

To facilitate summarizing the six years' results the total value of the six crops from each plot is shown in the last column, and at the bottom of the table are shown the average increase in yield for each year and the total value of the six years' increase (1) for nitrogen under the four conditions, (2) for phosphorus in addition to nitrogen (2 tests each year), and (3) for potassium in addition

TABLE 7.—CROP YIELDS IN SOIL EXPERIMENTS, GREEN VALLEY FIELD

Soil plot No.	Sand ridge soil	Grain, bushels per acre						Total value of crops for 6 years
	Treatment applied.	1902 Corn	1903 Corn	1904 Oats	1905 Wheat	1906 Corn	1907 Corn	
1	None	68.7	56.3	49.7	18.3	32.9	35.3	$ 92.86
2	Lime	68.2	42.0	35.9	19.0	17.8	29.5	77.41
3	Lime, nitrogen	68.6	65.4	44.4	23.5	62.9	58.9	117.08
4	Lime, phosphorus	30.3	24.9	20.3	16.7	10.4	13.1	44.32
5	Lime, potassium	23.1	20.1	16.9	16.5	8.4	12.8	38.32
6	Lime, nitrogen, phosphorus	57.4	69.8	51.9	26.8	70.8	64.7	123.69
7	Lime, nitrogen, potassium	70.0	72.9	54.7	36.5	74.8	73.6	141.19
8	Lime, phosphorus, potassium	49.8	39.6	36.9	13.7	18.3	27.7	66.21
9	Lime, nitrogen, phosphorus, potassium	69.5	69.8	47.8	36.2	66.4	73.6	135.05
10	Nitrogen, phosphorus, potassium	57.2	66.1	50.0	26.5	66.0	71.9	122.47
Average gain for nitrogen		23.5	37.8	22.3	14.3	55.0	46.9	72.71
Average gain for potassium over nitrogen		6.8	3.8	3.1	11.2	3.8	11.8	17.79
Average gain for phosphorus over nitrogen		—5.9	.7	.3	1.5	—3.	2.9	.22

to nitrogen (2 tests each year). Nitrogen is so clearly the limiting element that the only question regarding phosphorus and potassium is, will either of them effect a further increase after nitrogen has been applied.

As an average of four tests covering six years, the addition of nitrogen to this sand soil has produced increases valued at $72.71 an acre, averaging $12.12 a year, at a cost of $15.00 a year for 100 pounds of nitrogen in dried blood. In one instance the increase produced has actually exceeded in value the cost of the nitrogen applied, if we disregard the cost and effect of the potassium. Thus, the total value of the six crops from Plot 5, treated with lime and potassium, is $38.32, while $141.19 is the corresponding value for Plot 7, which differs from Plot 5 only by the addition of nitrogen. Under these conditions 600 pounds of nitrogen costing only $90.00 have produced an increase of $102.87 per acre in six years.

So far as we have discovered this is the only instance where the use of commercial nitrogen has paid its cost.in the production of ordinary farm crops in Illinois, and even here we must not overlook the fact that $15 worth of potassium was associated with the $90.00 worth of nitrogen where this enormous increase was produced. While potassium without nitrogen produces no benefit on this sand soil, when applied with nitrogen the potassium has produced an average increase valued at $17.79 per acre in six years at a cost of $15.00, but in this case the influence and cost of the associated nitrogen must not be ignored. In no case has the total increase paid for the combined cost of the elements involved with nitrogen as one of them.

Potassium is evidently the second limiting element in this soil where decaying organic matter is not provided, but the limit of potassium is very far above the nitrogen limit.

During the six years Plot 7, receiving nitrogen and potassium, produced 291.3 bushels of corn (averaging 72.5 bushels a year), 54.7 bushels of oats, and 36.5 bushels of wheat, per acre. To produce the increase of Plot 7 over Plot 5 would require about 75 percent of the total nitrogen applied. Thus, there has been a loss of 25 percent of the nitrogen applied, which is a smaller loss than usually occurs where commercial nitrogen is used. Without doubt larger yields would have been produced, especially of corn, if 150 or 200 pounds of nitrogen per acre per annum had been used, which would have increased the cost of nitrogen to $22.50 or $30.00, respectively, per acre each year.

It need scarcely be mentioned that commercial nitrogen is used in these and other experiments in Illinois only to help discover what elements are limiting the crop yields. It should never be purchased for use in general farming, but, if needed, secured from the atmosphere by legume crops to be returned to the soil directly or in manure.

It is interesting to note that on the sand soil the six years' increase from $15.00 worth of phosphorus (even when applied with nitrogen) is valued at only 22 cents.

On three other series of plots on the Green Valley soil experiment field a three-year rotation of corn, oats, and cowpeas was practiced, every crop being represented every year. On plots receiving lime and phosphorus and legume crops as green manure, the yield of corn was 45.6 bushels in 1906 and 67.8 bushels in 1907, compared with 70.8 bushels and 64.7 bushels with lime, phosphorus, and nitrogen on Plot 6 (see Table 7), and with 10.4 bushels and 13.1 bushels with no nitrogen on Plot 4, for the respective years. On other plots receiving comparable treatment, where lime, phosphorus, and potassium were used with nitrogen-gathering legume crops as green manure, the corn yields in the three-year rotation were 54.6 bushels in 1906 and 51.5 bushels in 1907, compared with 66.4 bushels and 73.6 bushels on Plot 9 with nitrogen applied, and compared with 18.3 bushels and 27.7 bushels on Plot 8 with no nitrogen for the same years.

The growing of legume crops and the use of farm manure (and possibly limestone) are the only recommendations made for the improvement of these well-drained sand ridge soils, altho further tests may show profit from potassium until more organic matter is supplied. As a rule clover cannot be grown successfully on this land, except in very favorable seasons, but cowpeas and soybeans are well adapted to such soil and they produce very large yields of excellent hay or of grain very valuable for feed and also for seed.

Under the best conditions, with good preparation and heavy manuring, alfalfa can be grown on this sand soil, more than five tons of alfalfa hay per acre in one year having been grown on part of the Green Valley field. Both soybeans and alfalfa should be inoculated with the proper nitrogen-fixing bacteria. (See Plate 7.)

Heavy applications of ground limestone also may be especially beneficial in getting alfalfa started.

For more detailed information the reader is referred to Bulletin 76, "Alfalfa on Illinois Soil," Bulletin 94, "Nitrogen Bacteria and Legumes," and Circular 110, "Ground Limestone for Acid Soils."

SOURCES AND USE OF POTASSIUM

From the results given in the preceding pages, the fact will be appreciated that the element potassium is a commodity of value, especially for the farmer who has to deal with peaty swamp soils. The commercial value of potassium is about 6 cents a pound for the element in soluble form. There are three common forms of potassium on the market: potassium chlorid, which contains about 42 percent of potassium; potassium sulfate, also containing 42 percent of potassium; and kainit, a crude mineral, containing only 10 percent of potassium. Potassium chlorid is frequently, but very incorrectly, called "muriate of potash." Potassium chlorid contains the two elements potassium and chlorin, as the name indicates. The word "muriate" has no meaning except that the ending *ate* indicates that the compound contains oxygen, which is not the case. "Potash" is a compound of potassium and oxygen, which is not contained in potassium chlorid. It is certainly better for the farmer to say potassium and potassium chlorid and be correct and intelligent about it than to say "potash" and "muriate of potash," and be confused and ignorant as to the nature of the compound.

It should be understood that the law of Ilinois requires that every bag of potassium fertilizer sold in the state shall bear a printed label stating the percentage of the element potassium which

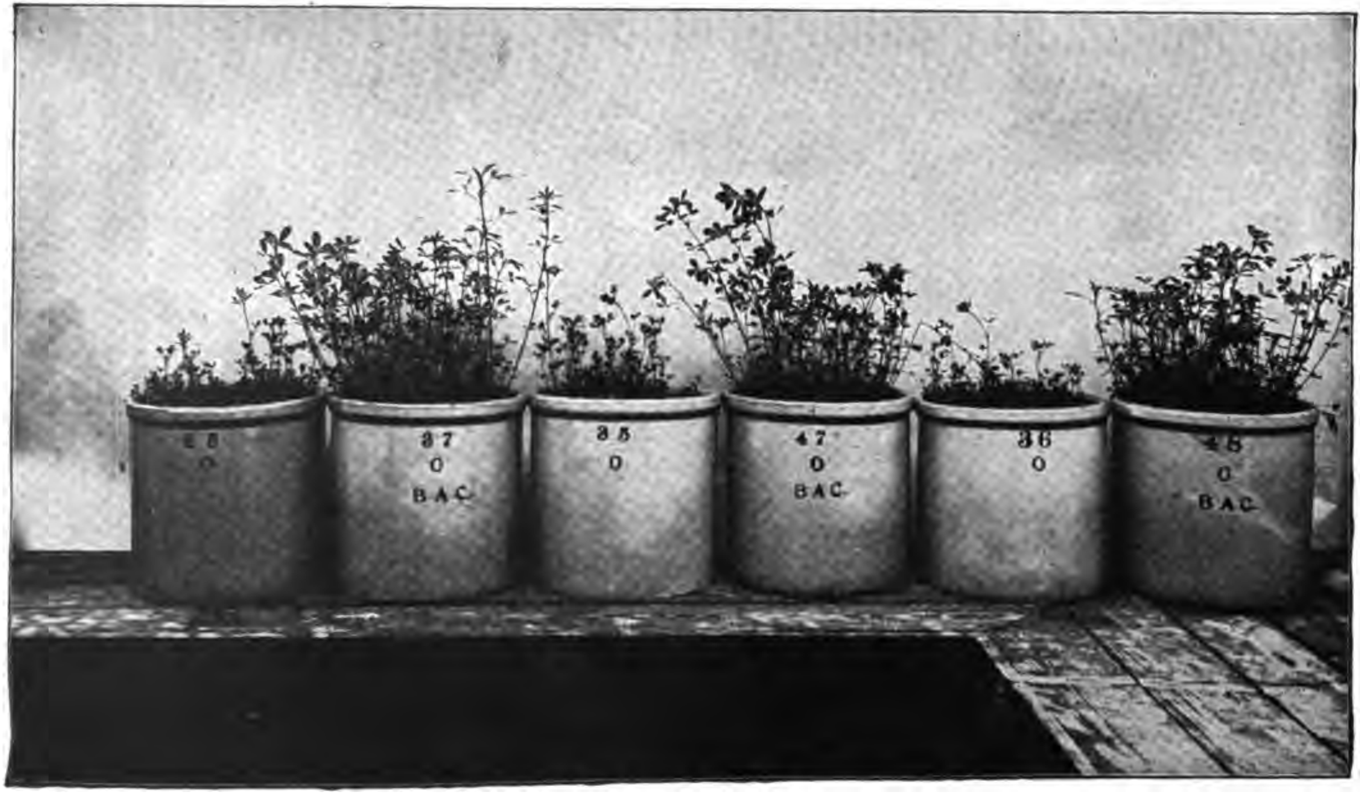

PLATE 7. TRIPLICATE TESTS OF THE EFFECT OF ALFALFA BACTERIA IN GROWING ALFALFA IN ORDINARY SOILS WITHOUT FERTILIZERS. JARS MARKED "BAC." CONTAIN ALFALFA BACTERIA.

the material contains, as well as the total number of pounds of material contained in the bag.

If a bag is marked "200 pounds" and the label "42 to 44 percent potassium," this means that the 200 pounds of material contains about 42 percent (or 42 pounds in 100 pounds) of the element potassium, which would make 84 pounds of potassium in the bag, or 840 pounds in a ton, which, at 6 cents a pound, would make the salt worth $50.40 a ton.

If the bag is marked "200 pounds" and the label "10 to 11 percent potassium," this means that the bag contains 20 pounds of the element potassium, which would make 200 pounds of potassium in a ton. At 6 cents a pound for potassium, this material would be worth $12 a ton.

It is true that fertilizer dealers frequently print on the bag the equivalent percentages of "potash," "muriate of potash," "sulfate of potash," etc., the chief effect of which is to make "big figures" and confuse the purchaser, but any farmer can understand the matter of buying potassium if he will look for the percentage of potassium. This is the number of pounds of potassium contained in 100 pounds of the material. A ton would contain 20 times as much potassium, and this is worth about 6 cents a pound in Chicago.

When we remember that a hundred-bushel crop of corn contains 73 pounds of potassium (19 in the grain, 2 in the cob, and 52 in the stover) besides that contained in the roots, it will be seen that 200 pounds of potassium chlorid (84 pounds of the element) will be barely sufficient for the first crop. If, however, only the ear corn is removed from the land, the stalks being pastured and plowed under, only 21 pounds of potassium are actually removed from the soil each year, even with a very large crop, the larger part of the potassium being thus left for the benefit of succeeding crops. Of course the potassium in the stalks is much less readily available than that in potassium chlorid. Nevertheless, as the stalks decay, the potassium will gradually become available. If the stalks are burned, the potassium remains in the ashes, but usually these are left in windrows, and consequently not well distributed for the next crop.

Farm manure contains about 8 pounds of potassium in a ton, but most farm manure decays slowly, a fact which is evidenced by the lasting effect of manure, its value being commonly greater for the second crop than for the first after its application, while many succeeding crops may show its effect. Horse manure decays much more quickly than cattle manure, and consequently the potassium in horse manure is quite readily available. The potassium in ordinary manure and in corn stalks is probably not worth less than

5 cents a pound, as compared with 6 cents a pound for soluble potassium. On this basis, for use on peaty swamp soils, rich in organic matter, nitrogen, and phosphorus, ordinary farm manure is worth about 40 cents a ton when potassium chlorid is worth $50 a ton. It should not be forgotten that one ton of potassium chlorid contains as much potassium as 100 tons of average fresh farm manure. Manure would be worth only 48 cents a ton for potassium if the potassium were all readily available.

It is certain that if we are raising corn on peaty swamp soil, rich in everything except potassium, and if less than one-third of the potassium absolutely required to make a crop is actually removed in the ear corn, it is very unscientific and very poor farm practice to be stingy with the potassium which we supply. On such soils as those on which our experiment fields are located at Tampico, Momence, and Manito, not less than 200 pounds of potassium chlorid per annum should be applied for the first one or two years. After that, if the stalks are not removed from the land, probably 100 pounds a year will be sufficient, and perhaps this can finally be reduced to 50 pounds a year, as this would furnish 21 pounds of potassium a year, which is as much as would be removed in one hundred bushels of ear corn.

It is well known that in ordinary soils potassium applied in soluble form is not lost by leaching, and it is evident from the experiments reported in this bulletin, especially those on the Manito fields, that peaty soil also has some power to fix and hold potassium from one year to another, even during seasons of abundant rainfall.

METHODS OF APPLYING POTASSIUM SALTS TO THE LAND

Potassium salts should be applied in the spring, preferably one or two weeks before the corn is planted. The material should never be applied in the hill with corn, for the reason that it may destroy the germinating power of the seed or injure the young plant, and also because the roots of the corn plant do not stay in the hill, but they grow out thru the soil in all directions, absorbing moisture and plant food. Corn fertilized in the hill, if the seed or young plants are not injured, frequently makes an abnormally strong growth for a few weeks, and later in the season suffers from dry weather more than ordinary corn, whose roots have developed more normally.

Potassium or other fertilizing material should be applied broadcast or in narrow drills, as a general rule. Any salt of potassium may be applied easily and quickly by hand, sowing or scattering it from the wagon. One farmer in Whiteside county reports having applied by hand 100 pounds to the acre over 22 acres of land in less than three-quarters of a day, a boy being provided to drive the team. Sowing potassium chlorid by hand is less difficult than sowing wheat or oats by hand, because of the necessity of securing a uniform stand of wheat or oats, while it would matter but little if there should be a few square feet now and then which received no potassium. It passes into solution before it becomes fixed in the soil and will thus be distributed somewhat, and the subsequent preparation of the seed bed and the cultivation of the corn will tend to mix it more uniformly with the soil.

An end gate seeder is a very good implement for applying potassium salts. Probably most farmers could apply the material about as rapidly and more uniformly with an end gate seeder than by hand, but it must be fed into the end gate seeder almost continuously, and in no larger amount than is necessary to keep the seeder working properly. (The hopper should never contain more than a few handfuls.)

It is good practice to apply the potassium and mix it with the soil by disking, before plowing, altho fairly good results are secured if it is applied after plowing and mixed with the soil in the usual preparation of the seed bed. It should not be applied when the ground is frozen if there is likely to be any overflow or surface drainage before the potassium salt dissolves and soaks into the soil.

"ALKALI" SOILS

It should be understood that the peaty swamp soils reported in this bulletin are not the same as the so-called "alkali" or "bogus" soils of the common heavy loam types. These "alkali" spots are very numerous in central and northern Illinois. They usually occur in the midst of the very best farming lands. They vary in size from a few square rods to several acres.

The most common kind of so-called "alkali" spot which we have found does contain alkali, and the soil is not improperly called alkali soil. The alkali, however, is not sodium carbonate, the ordinary strong alkali of the soils of arid countries, but it is magnesium carbonate, a mild alkali. The magnesium carbonate is usually associated with much larger quantities of calcium carbonate (limestone is calcium carbonate). Altho magnesium is one of the essential elements of plant food, yet an excessive amount of magnesium carbonate and bicarbonate becomes poisonous to plants, especially to corn and millet.

Usually the magnesium carbonate is more concentrated in the subsoil than in the surface, and if we can provide perfect underdrainage and prevent so far as possible the magnesium carbonate and more soluble bicarbonate from rising to the surface, and also provide abundance of plant food in the surface soil so that the corn roots are not required to live in the subsoil, these alkali soils can be made to grow good corn. In some cases applications of potassium salts may prove beneficial, but as a rule the most practical method for improving these soils is to provide good, deep underdrainage and then plow under organic matter, such as straw, farm manure, green oats, weeds, etc. This material helps the drainage, tends to prevent the rise of the alkali by retarding surface evaporation, and as it decays it liberates plant food in the surface soil, and it may be that organic acids are also liberated which unite with the magnesium to form less harmful compounds.

We have already ascertained that the magnesium can be removed from the soil by leaching or drainage after being transformed into the perfectly soluble magnesium sulfate by the double decomposition of magnesium carbonate and calcium sulfate, leaving behind harmless calcium carbonate (limestone), but whether the quantity and cost of calcium sulfate (gypsum, or land plaster) and the time required for the leaching process will prove to be too great to permit this to be done economically is not yet determined.

If no manure or other material is at hand, it is well to sow oats on these spots, and if they grow rank and fall down plow them under. One or two heavy crops of green oats plowed under will usually put the soil in condition to grow one or more crops of corn, and with perfect drainage these soils will usually improve with heavy cropping, for they are frequently very rich in all elements of plant food. Plenty of tile, laid deep and made to *work* (if necessary by surrounding them with straw, corn cobs, brush, etc.) is all that some of these "alkali" spots need to make them grow good corn.

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UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 158

RELATIVE ECONOMY, COMPOSITION AND NUTRITIVE VALUE OF THE VARIOUS CUTS OF BEEF

By L. D. HALL and A. D. EMMETT

URBANA, ILLINOIS, JULY, 1912

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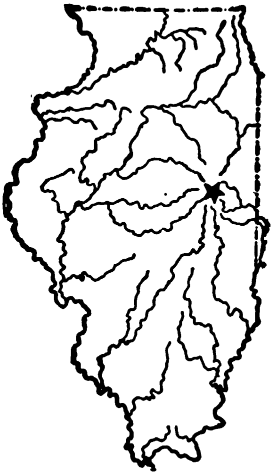

URBANA, ILLINOIS, JULY, 1912

SUMMARY OF BULLETIN No. 158

1. INTRODUCTION.—A knowledge of the market products into which beef cattle are converted is essential both to the producer and to the consumer of beef. Owing to the increasing cost of meats, there is a growing demand for accurate information on the subject. Pages 135 to 136

2. OBJECTS.—To determine (1) relative proportions of lean, visible fat, and bone in each of the retail and wholesale cuts of beef; (2) chemical composition and nutritive value of edible meat in each wholesale cut; and (3) net cost of the lean, the total edible meat, and the nutrients in each cut at current market prices. Page 137

3. ANIMALS USED.—No. 1: Choice grade Hereford steer, age 18 months, live weight 902 pounds. No. 2: Choice grade Aberdeen-Angus steer, age 24 months, live weight 1190 pounds. No. 3: Prime pure-bred Shorthorn steer, age 29 months, live weight 1,360 pounds. Pages 137 to 139

4. SLAUGHTER TESTS.—Weights of dressed beef, hides, fats, and of the various organs and other parts comprising the offal were recorded and reduced to percentage of live weight. Pages 139 to 141

5. WHOLESALE CUTS.—The right half of each carcass was divided into the "straight" wholesale cuts, viz., loin, rib, round, chuck, plate, flank, and fore shank; also four minor wholesale cuts, the rump, hind shank, shoulder clod, and neck. Each cut was weighed and the percentage of carcass weight calculated. Pages 142 to 144

The amounts and proportions of lean, fat, and bone in each wholesale cut were determined, and the relative economy of the cuts at wholesale market prices was computed. Pages 144 to 147

6. CHEMICAL COMPOSITION AND NUTRITIVE VALUE.—The boneless meat of each wholesale cut was analyzed to determine the proportions of water, protein, fat (ether extract), organic extractives, mineral matter, and phosphorus. Pages 148 to 159

From the chemical composition and the calculated fuel value of the boneless meat, the relative nutritive economy of the wholesale cuts at market prices was determined. Pages 159 to 163

7. RETAIL CUTS.—Each wholesale cut was divided into its proper retail cuts. After weighing, photographing, and trimming such cuts as are ordinarily trimmed of surplus fat and bone, each retail cut was separated into lean, visible fat, and bone, and each portion weighed. Pages 163 to 170

Relative economy of the various cuts was computed in terms of the cost per pound of lean and of total meat in each cut at retail market prices. Pages 170 to 173

8. CONCLUSIONS. Pages 173 to 177

9. PHOTOGRAPHS OF THE RETAIL CUTS. Pages 177 to 200

10. APPENDIX.—Tabulated results of cutting and trimming the wholesale and retail cuts, and of the chemical analyses of the wholesale cuts from the three half carcasses. Pages 200 to 233

RELATIVE ECONOMY, COMPOSITION AND NUTRITIVE VALUE OF THE VARIOUS CUTS OF BEEF[1]

BY L. D. HALL, ASSISTANT CHIEF IN ANIMAL HUSBANDRY, AND
A. D. EMMETT, ASSISTANT CHIEF IN ANIMAL NUTRITION

INTRODUCTION

Precise knowledge of the final market products into which beef cattle are converted is essential both to the producer and to the consumer of beef. In order to place beef production upon the most exact and profitable basis, account must be taken not only of economical methods of breeding and feeding, but also of the quality of the finished beef product as delivered to the ultimate consumer. The relative efficiency of different types of beef cattle or of systems of production cannot be accurately compared without considering the adaptability of the beef to the purpose for which it is used. The same considerations that prompt manufacturers of other food articles to study closely the commodities they place on the market should prompt the meat producer to inform himself as thoroly as possible regarding his finished product. Notwithstanding the evident truth of these propositions, no comprehensive studies have yet been conducted and published which furnish a basis on which to compare live cattle with the various cuts of beef derived from their carcasses. Consequently, beef producers have continued to conduct their operations almost wholly without regard to this important phase of the industry.

Meat-market patrons are more directly, altho no more vitally concerned with this subject than beef producers, since they deal directly with the market and have occasion almost daily to make use of information concerning the relative values of the different retail cuts. Those who would buy meat most intelligently must know the nature of these cuts, especially with reference to the proportions of lean meat, fat, and bone which they contain and the food value of meat from different parts of the carcass. A large majority of meat consumers have no knowledge whatever of these matters, but make their selections of meat solely according to habit or fancy. In fact, but little accurate data along this line have hitherto been available to those who wished to buy meats on a rational basis. As a result, a few well-known cuts are greatly in demand, and the remainder of the carcass is a "drug on the market." To such an extreme has this condition developed that a portion of the carcass (loins and ribs), forming only about one-fourth of its weight, represents nearly one-half of its retail cost. In view of the large place which meat occupies in the American diet, amounting to nearly one-third of the average expenditure for all food, the importance of an intelligent understanding of the subject on the part of the consumer is readily apparent.

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[1] The investigations herein reported relative to the retail cuts of beef were suggested by Herbert W. Mumford, Chief in Animal Husbandry, and those relating to chemical composition and nutritive value of the wholesale cuts, by H. S. Grindley, Chief in Animal Chemistry. The work was planned jointly under their general supervision, together with their associates, L. D. Hall and A. D. Emmett. Messrs. Grindley and Emmett were entirely responsible for the chemical analysis of the wholesale cuts, and rendered material assistance in connection with the slaughter tests, physical determinations, and in the compilation of the data on the retail cuts.

Not only are the foregoing statements true of meat producers and consumers as individuals, but it is highly essential to the entire beef-cattle industry, on the one hand, and the economic welfare of the beef-eating public, on the other, that a more intelligent understanding of the different cuts of meat be acquired by consumers generally. An increased demand for those portions of the carcass which are now difficult for the butcher to dispose of would contribute largely toward a more stable condition of the trade and thus enable the producer to operate with greater confidence and economy. At the same time it would effect a tremendous saving to the consumer himself by more nearly equalizing the market values of the various cuts and by enabling the retailer to operate with a smaller margin of profit. A thoro awakening of our own people in this matter is no less essential to the future of beef production in this country than the development of our foreign markets, on the one hand, or a more efficient system of cattle raising, on the other. Thus producer and consumer are in a large sense inter-dependent with respect to the whole question, and the dissemination of useful information along this line is clearly to their mutual advantage. Further, cattle raisers themselves constitute an important proportion of the beef-consuming class; hence they have a two-fold interest in the matter. The increasing cost of meats, in keeping with prices of other foods, has stimulated popular interest in the whole subject, and there is a growing demand for accurate information bearing upon it.

OBJECTS AND PLAN OF INVESTIGATION

The principal objects of the investigation reported in this bulletin were to determine (1) the relative proportions of lean, visible fat, and bone in each of the retail and wholesale cuts of beef; (2) the chemical composition and nutritive value of the boneless meat (all lean and fat) of the various wholesale cuts; and (3) the net cost to the consumer of the lean, the gross meat, and the food nutrients in each cut at current market prices. Incidentally, data were obtained relative to the amounts and proportions of the various internal organs and other by-products of slaughter yielded by cattle.

Steers from the University herd were slaughtered at a local abattoir, the weights of hides, fats, various internal organs, and other by-products being recorded, as well as those of the different live animals and their dressed carcasses. After proper refrigeration in a cold storage room at the abattoir, the right half of each carcass was brought to the laboratory and divided into wholesale cuts; and these in turn were cut up as in retail markets. Some of the retail cuts were trimmed free of surplus fat and bone in accordance with meat-market custom, and the lean, fat, and bone of each cut were then separated as carefully and completely as could be done by the use of boning knives. A composite sample of all the boneless meat derived from each wholesale cut was taken for chemical analysis. Each step in the slaughtering, cutting, and sampling was performed rapidly in order to minimize loss by evaporation, and careful precautions were observed to make the records exact and complete.

ANIMALS USED

These tests were made upon the carcasses of three steers: a choice grade Hereford, a choice grade Aberdeen-Angus, and a prime pure-bred Shorthorn.

Steer No. 1, the grade Hereford, was one of a carload of choice calves from the Panhandle of Texas, purchased by the University in December, 1904, at the International Live Stock Exposition in Chicago. They were spring calves (April and May, 1904) and ran with their dams on grass without grain until November, 1904, when they were shipped to Chicago. About December 10 they were shipped to the University, where they were gradually placed on a fattening ration consisting of crushed ear corn, cottonseed meal, clover, and alfalfa hay, with a small amount of corn stover, and continued on full grain feed until marketed in November (1905). Pure corn meal was used during a part of the feeding period instead of crushed ear corn, and linseed meal was used instead of cottonseed meal part of the time. This steer was about eighteen months old when slaughtered November 14, 1905. It was a choice yearling in prime condition but not fancy in quality nor form, and would have sold at twenty-five to fifty cents per hundred weight below the top of the beef-cattle market. Thru an oversight Steer No. 1 was not photographed.

Steer No. 2, a grade Aberdeen-Angus, was bought as a calf in the fall of 1904 and was used as a specimen steer for the class in stock judging. It was fed a ration of three parts corn, one part oats, one part bran, and one part oil meal together with clover hay, and was on pasture about five months in the summer of 1905. When slaughtered (March 20, 1906, age 24 months) it was a choice beef steer, sufficiently fat but not quite good enough in quality nor form to grade prime. See Fig. 1.

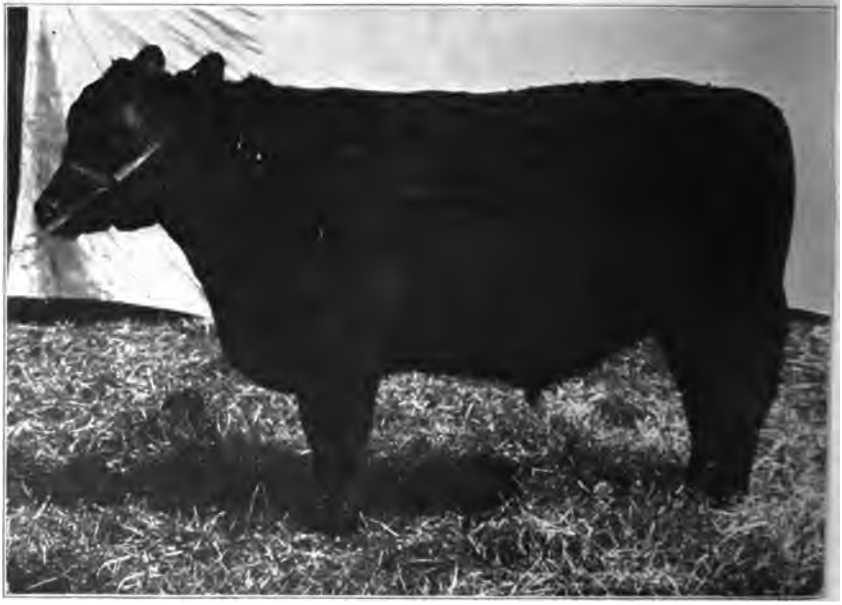

FIG. 1. CHOICE ABERDEEN-ANGUS GRADE STEER.

Steer No. 3, the Shorthorn (Fig. 2), was bred and raised at the University. It was calved in May, 1904; ran on pasture and was fed milk at the pail during the first summer; received a light ration of three parts corn, three parts oats, three parts bran, and one part oil meal during the winter; ran on pasture during the summer of 1905; and was changed to a ration of three parts corn, one part oats, one part bran, and one part oil meal during the following winter, which ration, together with clover hay in the winter and pasture in the summer, it was fed until slaughtered October 22, 1906, at 29 months. At the time of slaughtering, this steer graded strictly prime, somewhat over-ripe in condition, but fancy in quality and form, being the best of the three steers in these respects. The carcass was cut up October 25, 1906. All the photographs of retail cuts reproduced in this bulletin (Figs. 13 to 69) were made from this carcass.

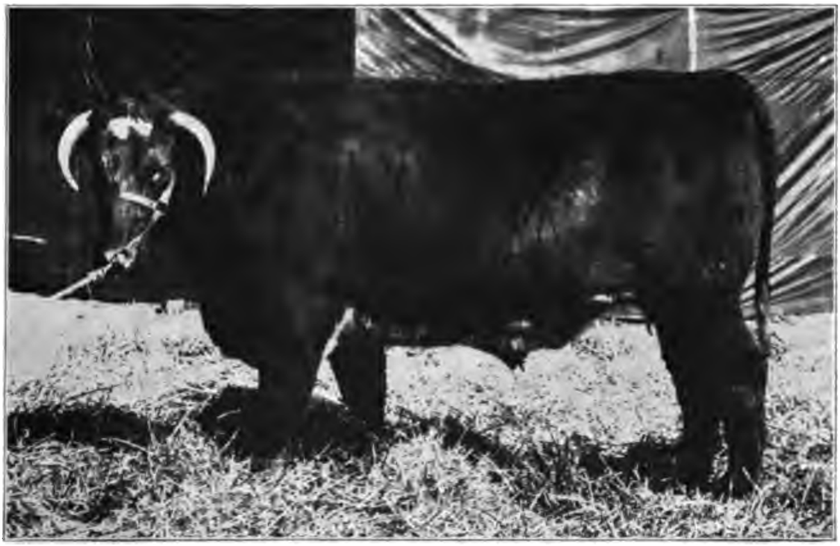

FIG. 2. PRIME PURE-BRED SHORTHORN STEER.

The reader is cautioned against regarding this experiment as a comparison of the three breeds of cattle involved. The differences observed in the carcasses and in the cuts of beef must be attributed chiefly to differences in age, condition (fatness) and individuality of the animals. It also should be borne in mind that the results of this investigation are not in all respects applicable to the medium and lower grades of beef.

SLAUGHTER TESTS

The cattle were fasted twenty-four hours before slaughtering, but were given water. The live weight was taken at the abattoir immediately before slaughtering. Table 1 shows the weights recorded in connection with the slaughter test and the percentage of carcass and of by-products based on the live weight.

Comparatively little shrinkage occurred in cooling the carcasses, owing to insufficient ventilation and a high degree of mois-

TABLE I.—RESULTS OF SLAUGHTER TESTS

	Steer No. 1, pounds	Steer No. 2, pounds	Steer No. 3, pounds	Steer No. 1, percent	Steer No. 2, percent	Steer No. 3, percent
Live weight	902.0	1190.0	1360.0			
Dressed beef, warm	549.0	739.0	870.0	60.86	62.10	63.97
Dressed beef, cold	544.5	724.5	870.0[1]	60.36	60.88	63.97
Shrinkage	4.5	14.5	0	.50	1.22	0
Right half cascass	274.3	357.5	430.0	30.41	30.04	31.62
Left half carcass	270.2	367.0	440.0	29.96	30.84	32.35
Hide	67.5	77.5	87.5	7.48	6.51	6.43
Fats						
Total	46.5	71.0	64.1	5.15	5.97	4.71
Caul	16.0	29.4	24.5	1.77	2.47	1.80
Intestinal	22.5	31.4	23.5	2.49	2.64	1.73
Pluck	8.0	10.2	16.1	.89	.86	1.18
Tongue	5.1	3.8	6.2	.57	.32	.46
Heart	3.9	4.4	5.5	43	.37	.40
Liver	13.0	13.6	14.0	1.44	1.14	1.03
Sweet breads	.6	1.0	.9	.07	.08	.07
Lungs	5.8	5.5	7.0	.64	.46	.51
Trachea (windpipe)	2.5	3.0	1.7	.28	.25	.12
Penis	.5	1.0	.8	.06	.08	.06
Tail	1.6	1.6	1.6	.18	.13	.12
Stomachs						
Total, with contents	86.8	119.5	134.0	9.62	10.04	9.85
Rumen and reticulum, empty	18.3	18.0	22.5	2.03	1.51	1.65
Rumen and reticulum with contents	66.3	98.0	102.5	7.35	8.23	7.33
Omasum and contents	10.5	16.0	20.0	1.16	1.35	1.47
Abomasum, empty	10.0	4.5	10.3	1.11	.38	.76
Abomasum and contents	......	5.5	11.5	......	.46	.85
Intestines	33.0	33.4	43.0	3.66	2.81	3.16
Spleen	4.0	1.6	1.9	.44	.13	.14
Gall bladder and contents	......	1.0	1.7	......	.08	.12
Head						
Total	21.5	27.5	30.0	2.38	2.31	2.21
Bone	12.0	15.0	22.5	1.33	1.26	1.65
Trimmings	9.5	12.5	7.5	1.05	1.05	.55
Fore feet						
Total	7.3	7.5	9.2	.81	.63	.68
Bone	6.0	6.0	8.0	.67	.50	.59
Trimmings	1.3	1.5	1.2	.14	.13	.09
Hind feet						
Total	7.0	7.5	9.5	.78	.63	.70
Bone	5.5	6.0	7.5	.61	.50	.55
Trimmings	1.5	1.5	2.0	.17	.13	.15
Blood	29.0	35.2	43.5	3.22	2.96	3.20
Loss in dressing	17.4	32.8	27.65	1.93	2.76	2.03

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[1] No shrinkage, due to humidity of the cooler and fat condition of carcass.

ture in the atmosphere of the chillroom, which retarded radiation of moisture from the beef. Carcasses Nos. 1 and 2 remained in cold storage 44 hours after dressing and No. 3, 68 hours at a temperature of 38° to 40° F. Notwithstanding the longer period of chilling, carcass No. 3, being extremely fat, showed no shrinkage; and the others sustained much less loss than commonly occurs under normal packing-house conditions.

Referring to the percentage of dressed beef (cold basis), it is found that Steer No. 3 gave the highest yield and Steer No. 1 the lowest. Had the relative weight of undigested food in the stomach at the time of slaughter been the same as in the case of Steer No. 1, the dressed yield of Steer No. 2 would have been 61.80 percent and that of No. 3, 64.40 percent, thus comparing even more favorably with Steer No. 1 than is indicated by the yields based on actual live weight, as in Table 1. The variations in yield were due, chiefly, to the fatter condition of Steer No. 3 and the thinner condition of No. 1, but they were influenced to some extent by differences in conformation and quality of the cattle.

The smallest relative weight of internal fat was yielded by Steer No. 3, and the highest by Steer No. 2. Considering the high condition of Steer No. 3 and the large percentage of dressed beef netted by this animal, the small proportion of internal fat is significant, indicating a high degree of efficiency for beef production.

Relative weights of the various organs and parts of the three animals are scarcely comparable, being influenced to an unknown extent by the differing degrees of condition and "fill" already mentioned. It will be noticed, however, that the body of Steer No. 1 contained the largest relative weight of organs and parts that constitute the offal,[1] due in part to lower condition and consequently smaller percentage of carcass to live weight, and doubtless, also, to a natural tendency to coarseness of bone, skin, and general quality. Steer No. 2, on the other hand, altho lower in condition and therefore in carcass yield than No. 3, yielded a smaller percentage of bone than the latter, as shown by figures for the head and feet, also a smaller proportion of various internal organs such as the paunch and intestines, and a similar percentage of hide; thus indicating that the highest degree of general quality, as between the three steers, was possessed by No. 2.

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[1] By-products other than the hide and fats.

WHOLESALE CUTS

After chilling, the right half of each carcass was taken to the laboratory for cutting and sampling. Altho cut up on different dates, the cutting in each instance was done by the same man, an expert from the packing-house market of Swift and Company, Chicago, and identical methods of procedure were observed as nearly as possible with the three carcasses.

The accompanying diagram (Fig. 3) illustrates the wholesale cuts that were made. In addition to the seven "straight" cuts, four secondary wholesale cuts were made; viz., the hind shank, rump, clod, and neck. In the section on retail cuts they are included with the respective "straight" cuts to which they belong.

RELATIVE WEIGHTS OF THE VARIOUS CUTS

Results of the cutting tests are summarized in the following table. The weights were taken in terms of pounds and ounces but are here reduced to decimals for convenience of comparison.

TABLE 2.—WEIGHTS AND PERCENTAGES OF THE STRAIGHT WHOLESALE CUTS

	Steer No. 1, pounds	Steer No. 2, pounds	Steer No. 3, pounds	Steer No. 1, percent	Steer No. 2, percent	Steer No. 3, percent	Average percent
Loin	42.58	63.45	70.46	15.75	17.71	16.60	16.76
Rib	26.53	35.78	40.52	9.81	9.99	9.54	9.77
Round	60.15	77.12	92.11	22.25	21.53	21.70	21.78
Chuck	61.86	77.07	91.55	22.88	21.52	21.56	21.89
Plate	40.13	51.95	72.50	14.84	14.50	17.08	15.63
Flank	14.53	19.30	20.37	5.37	5.39	4.80	5.15
Fore shank	13.93	16.50	21.96	5.15	4.61	5.17	4.97
Kidney suet	10.65	17.03	15.06	3.94	4.75	3.55	4.06
Entire side	270.36	358.20	424.53	99.99	100.00	100.00	100.00

The proportions of the various cuts as shown above are similar in the three carcasses. The percentages correspond in general to average results of other tests on prime steers. Steer No. 1 appears to have been relatively lightest in loin and heaviest in round and chuck; Steer No. 2 shows the largest percentage of loin, rib, and kidney suet, and the smallest shank; Steer No. 3 was lowest in percentage of rib, round, chuck, flank and kidney suet, and highest in shank and plate. To what extent these differences are due to unavoidable variations in the cutting of the carcass, it is

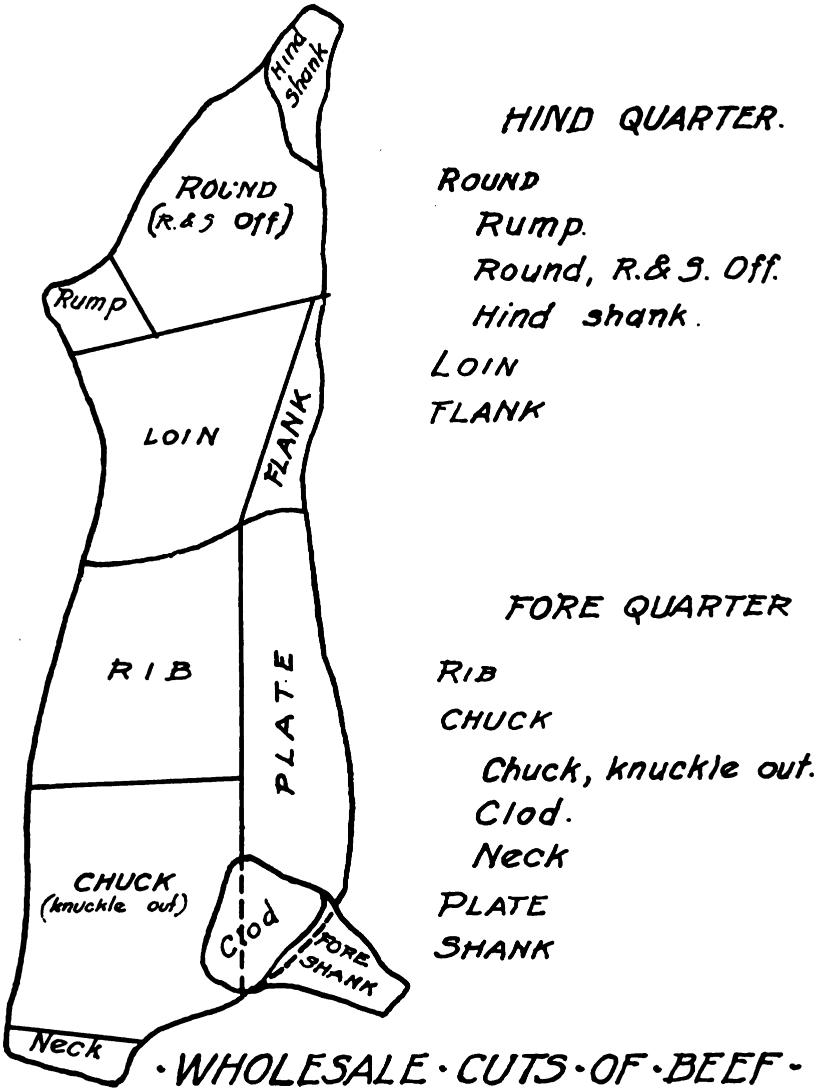

FIG. 3. METHOD OF CUTTING THE THREE SIDES, SHOWING WHOLESALE CUTS.

impossible to say, but probably this factor exercised considerable influence. For instance, the large percentage of plate in Steer No. 3, considered in connection with the small percentage of rib and chuck, indicates that the plate was cut slightly higher on the side than was the case in the other carcasses. The large percentage of round compared with the small percentage of loin in the

Hereford suggests that the round probably received a slight advantage in cutting this carcass. Undoubtedly, however, the carcass of Steer No. 2 had a larger actual proportion of loin and suet than the others; while that of Steer No. 1 was naturally heaviest in the chuck and lightest in the loin.

The total percentage of loin and rib is generally considered an important indication of the cutting value of a carcass; hence the following comparison will be of interest:

	Percent loin and rib
Steer No. 1	25.24
Steer No. 2	27.83
Steer No. 3	26.05

The relative proportions of the fore and hind quarters as expressed in the following table were calculated from the weights of wholesale cuts in each quarter.

TABLE 3.—WEIGHTS AND PERCENTAGES OF THE FORE AND HIND QUARTERS

	Steer No. 1, pounds	Steer No. 2, pounds	Steer No. 3, pounds	Steer No. 1, percent	Steer No. 2, percent	Steer No. 3, percent	Average percent
Fore quarter ...	142.45	181.30	226.53	52.69	50.68	53.36	52.21
Hind quarter....	127.91	176.42	198.03	47.31	49.32	46.64	47.79
Entire side	270.36	357.72	424.56	100.00	100.00	100.00	100.00

EDIBLE MEAT AND WASTE

The straight cuts may now be compared with reference to the relative proportions of lean, visible fat, and bone which they contain. For the sake of convenience and brevity, the discussions relative to the food values and waste of the various wholesale and retail cuts will be confined to the *average* results obtained from the three carcasses and will be stated in percentages. The complete data on which the averages are based will be found in the appendix. The following table is based upon the sum of the data derived from the various retail cuts into which each wholesale cut was divided.

This summary shows that the three sides used in this test averaged about 57 percent lean meat, 30 percent visible fat, and 12 percent bone. The proportion of lean in the various cuts (except the kidney) varied from about one-third in the flank to about two-thirds in the chuck; the extreme percentages of visible fat were 11 percent in the fore-shank and 63 percent in the flank; and the percentage of bone ranged from practically nothing, in the

TABLE 4.—PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE STRAIGHT WHOLESALE CUTS

Straight wholesale cuts	Lean	Fat	Bone	Total
Loin	58.53	31.75	8.89	99.17
Rib	55.21	30.17	14.18	99.56
Round	64.61	18.03	16.63	99.27
Chuck	69.47	18.63	11.26	99.36
Plate	50.61	40.73	8.47	99.81
Flank	36.30	63.18	.25	99.73
Fore shank	47.61	11.63	40.20	99.44
Kidney suet	7.01[1]	92.99	0	100.00
Entire side	56.90	30.29	12.34	99.53

[1] Kidney.

flank, to 40 percent in the fore shank. From the data here given we may also calculate the relative amounts of lean, visible fat, and bone in the hind and fore quarters, with the following results: hind quarter, 54.42 percent lean, 34.55 percent visible fat, and 10.71 percent bone; fore quarter, 59.12 percent lean, 26.69 percent fat, and 13.73 percent bone.

In order to render the important data in Table 4 more easily studied, the following diagram (Fig. 4) is presented.

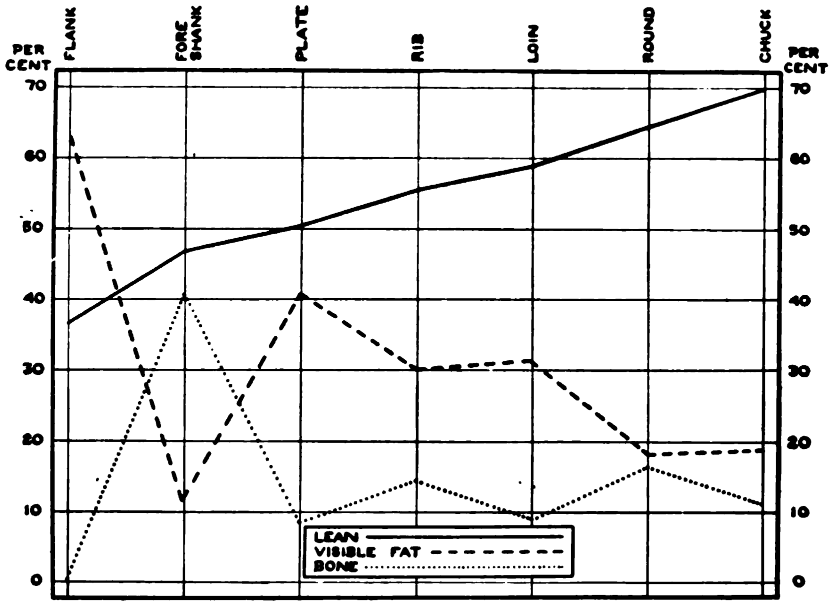

FIG. 4. PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE STRAIGHT WHOLESALE CUTS.

In this diagram, and in similar illustrations in the following pages, the various wholesale cuts are represented by vertical lines, each being designated at the top. The horizontal lines represent percentages, which are read by means of the numerical scale at the right and left. The irregular lines represent various constituents of beef, according to the key given on each diagram; thus their position and direction are determined by the percentage of each constituent contained in the different wholesale cuts.

Referring to Fig. 4, the heavy solid line shows the percentage of lean meat in each of the seven straight cuts, which are arranged from left to right in order of the percentage of lean which they contain. The minimum percentage of this constituent, about 36 percent, occurs in the flank and the maximum, about 70 percent, in the chuck; while the comparatively regular ascending course of the heavy line indicates various percentages of lean in other cuts between these extremes. Following the broken line from left to right it is evident that in general the percentage of fat varies inversely as the percentage of lean, the shank, however, being a prominent exception. The dotted line, representing the percentage of bone, shows less variation than do the others, but, with the exception of the shank, its general direction corresponds to the line showing the percentage of lean, and is opposite that of the fat. The large percentage of bone in the shank corresponds to its low percentage of fat, and in both constituents this cut varies widely from the others.

In general, the cuts containing a large percentage of lean have a small percentage of visible fat, and vice versa, while the relative weight of bone is more variable. The round and chuck are the leanest cuts of the carcass. Loin and rib cuts are intermediate with respect to lean, fat, and bone. The flank and fore shank are low in percentage of lean, the former being high in percentage of fat and the latter in proportion of bone.

RELATIVE ECONOMY OF MEAT FROM THE STRAIGHT WHOLESALE CUTS

The relative economy of the different cuts may be further expressed in terms of the net cost per pound of lean and of total meat (consisting of all the lean and visible fat) in each cut at market prices. This is calculated by dividing the percentage of each constituent into the market price per pound of the entire cut. Thus the cost per pound of lean is based on the proportion of lean contained in the cut in question, and the cost per pound of gross meat is determined from the total percentage of lean and fat. For this comparison wholesale prices are used, leaving the retail cost to be considered in connection with the various retail cuts. (Table 19).

TABLE 5.—COST OF LEAN AND OF TOTAL MEAT IN THE STRAIGHT WHOLESALE CUTS AT MARKET PRICES

Straight wholesale cuts	Wholesale price per pound of cut, cents	Cost per pound of lean in cut, cents	Cost per pound of total meat in cut, cents
Loin	18.5	31.6	20.5
Rib	15.0	27.1	17.5
Round	11.5	17.8	13.9
Chuck	9.5	13.7	10.8
Plate	8.0	15.8	8.7
Flank	8.0	22.0	8.0
Fore shank	5.0	10.5	8.4

The net cost per pound of lean is, in general, greatest in the cuts which command the highest prices, and vice versa. The flank is an exception to this rule, and the chuck is more economical in this respect than the plate. Referring to the last column it is also observed that the more expensive the cut, the greater the cost per pound of visible fat and lean combined, the flank being the only exception. From these figures it is apparent that food values of beef cuts do not correspond to their wholesale market prices, and that the cheaper cuts are by far the most economical sources of both lean and fat meat. On the whole, the different cuts vary more widely in net cost of food ingredients than in market price per pound of gross meat. The following discussion tends to confirm these statements.

CHEMICAL COMPOSITION OF THE BONELESS MEAT OF THE WHOLESALE CUTS

After separating each of the wholesale cuts mechanically into lean, visible fat, and bone, as already described, the lean and the visible fat were sampled for chemical analysis. The rump, hind shank, shoulder clod, and neck were sampled separately, thus making eleven cuts in all, as illustrated by Fig. 3 on page 143.

With Steers Nos. 1 and 2 the visible fat from all the cuts was composited and analyzed, while the lean meat from each of the cuts was subjected to a detailed chemical study. With Steer No. 3, however, the visible fat and lean of each cut were combined and analyzed. In none of these cases was the bone subjected to chemical analysis.

Methods of Analysis

The following determinations were made on the samples of boneless meat:

1. Water
2. Dry substance, water-soluble and insoluble
3. Fat, ether-soluble matter
4. Protein, water-soluble and insoluble
5. Organic extractives, nitrogenous and non-nitrogenous
6. Ash, water-soluble and insoluble
7. Phosphorus, water-soluble organic and inorganic, and water-insoluble

The methods used in making the chemical study of the various cuts of beef were those which have been published from the Laboratory of Physiological Chemistry of this department.[1] It is not the object of the writers to outline these methods at this time nor to discuss these technical data excepting in as practical a way as possible.

As in the preceding discussion, the corresponding data from the three steers have been averaged, and it is upon these average data that the statements herein are based. The detailed chemical results for each of the animals will, however, be found in full in the appendix. Attention should again be called to the fact that the animals used in these tests were choice and prime steers.

PERCENTAGES OF WATER, DRY SUBSTANCE, AND FAT IN THE BONELESS MEAT OF THE WHOLESALE CUTS OF BEEF

In the following table the data are given showing the distribution of water, dry substance, and fat in the boneless meat (all lean and fat) from the eleven cuts. The results are expressed in percentages calculated on the basis of the fresh substance.

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[1] Journal American Chemical Society, 27, 658-678, and 28, 25-64 (1905), Grindley and Emmett.

TABLE 6.—PERCENTAGES OF WATER, SOLUBLE AND INSOLUBLE DRY SUBSTANCE, AND FAT IN THE BONELESS MEAT OF THE WHOLESALE CUTS

Wholesale cut	Water	Dry substance				
		Other than fat			Fat	Total
		Soluble	Insoluble	Total		
Flank	32.26	1.73	8.88	10.61	57.16	67.77
Plate	39.42	2.29	9.89	12.16	48.57	60 75
Rib	45.15	3.06	11.23	14.29	40.62	54.91
Rump	46.25	3.33	11.42	14.75	38.95	53.70
Loin	47.42	3.48	11.69	15.17	37.71	52.88
Chuck	55.47	3.82	13.53	17.35	27.54	44.89
Neck	56.32	3.80	14.07	17.87	26.12	43.99
Fore shank	60.95	3.80	15.75	19.55	19.98	39.53
Hind shank	61.02	3.90	14.84	18.74	20.77	39.51
Round	60.86	4.89	14.55	19.44	19.65	39.09
Clod	63.04	4.48	15.02	19.50	17.96	37.46

In the above table dry substance refers to that portion of the flesh that is not driven off upon heating the sample at the boiling point of water, or the flesh minus the water contained in the cut. Fat includes not only visible fat but also all the ether extract derived from the so-called lean of each cut. The soluble dry substance is that portion of the meat which is dissolved out by pure water at ordinary room temperature. It is supposed that the water-soluble constituents of flesh are more easily and quickly digested than the non-soluble, and hence of greater use to the needs of the body. The insoluble dry substance other than fat is that portion which remains after treatment with water.

Water.—The cuts are arranged according to the percentages of water they contain. The percentage of water represents all that portion of each cut not included in the dry substance. The wide variation in water content of different cuts of beef is here shown in a striking manner, ranging from about one-third up to two-thirds of the weight of edible meat.

It will be noticed that the arrangement of the various cuts is substantially in inverse order with respect to the percentages of fat and of total dry substance; also that in general the higher the percentage of fat, the lower the percentage of water. Two of the cheaper cuts of the carcass, viz., the flank and plate, contain the lowest percentages of water, due to their large proportions of fat. The round and clod rank highest in respect to water because of the large percentages of lean meat they contain. The high-priced rib and loin cuts are intermediate.

Dry Substance.—The relationship between the dry substance content of the eleven wholesale cuts is shown graphically in Fig. 5. It will be seen that the upper curve gives the distribution of the percentages of total dry substance in the boneless meat. This curve rises continuously from the clod to the flank cuts, indicating an increasing percentage of dry substance with the fatter cuts. The cheaper cuts such as the shank, clod, and round have the smallest percentages of dry substance.

The order of increasing percentages of soluble dry substance shown by the second curve, corresponds, with the exception of a few minor rearrangements, to the order of cuts given in Fig. 6 for fat. It is seen that the expensive cuts are not at all favorably distinguished from the cheaper ones, the loin and rib cuts possessing, in fact, smaller percentages of soluble dry substance than the average-priced cuts. The round, however, a medium-priced cut, has the largest proportion of soluble matter, 4.89 percent; the clod comes next, having 4.48 percent; while the flank is lowest, 1.73 percent. The values for the loin and rib are respectively 3.48 and 3.06 percent.

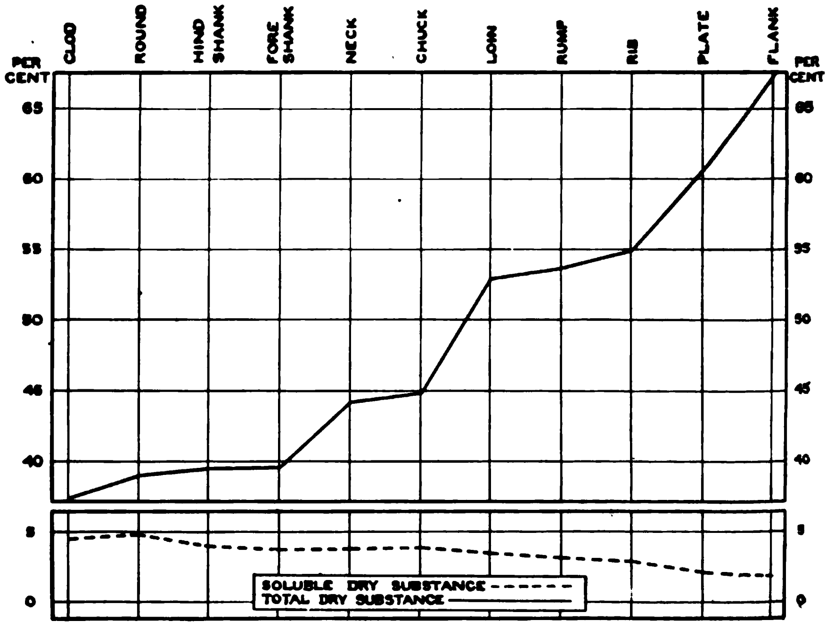

FIG. 5. PERCENTAGES OF TOTAL AND SOLUBLE DRY SUBSTANCE IN THE BONELESS MEAT OF THE WHOLESALE CUTS.

If the influence of the difference in fat be eliminated by calculating the soluble dry substance of each cut on the fat-free basis, the order of the cuts is considerably modified, as the following data show:

	Percent
Round	6.09
Loin	5.59
Clod	5.46
Rump	5.45
Chuck	5.27
Rib	5.15
Neck	5.14
Hind shank	4.92
Fore shank	4.75
Plate	4.45
Flank	4.04

The most significant rearrangements are those of the loin and rib cuts. According to these calculations the new arrangement of the cuts conforms more nearly to the order of their decreasing popularity as indicated by their market value, the round, loin, rump, chuck, and rib cuts, representing the most expensive portions of the beef carcass, clustering toward the top.

Fat.—The distribution of the fat among the cuts is represented in Fig. 6 by two curves, one on the fresh and the other on the dry basis. These two curves run approximately parallel. This latter

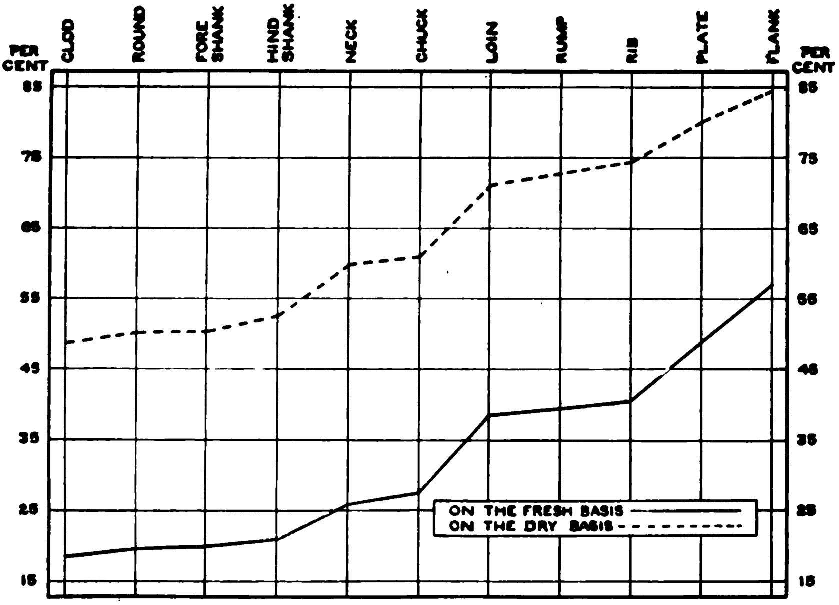

Fig. 6. Percentages of Fat in the Boneless Meat of the Wholesale Cuts.

relation indicates that an increase in the percentage of fat in a cut results in a decrease in the percentage of water. In view of the great differences between the various cuts as regards fat content, the question arises whether these differences do not largely or entirely account for the differences in the percentages of dry substance and water. This question is answered in part by eliminating the fat from the percentage of dry substance, that is, by calculating the percentage of dry substance other than fat to the fat-free basis. The uniformity of the data in this form leads to the conclusion that, as regards the water content of the boneless fat-free meat, the eleven cuts do not distinctly differ among themselves, being very nearly the same.

The differences among the eleven cuts of beef as to their content of fat is shown in the curves (Fig. 6). The extreme positions are occupied by the clod and round cuts, on one hand, and the plate and flank cuts, on the other. The loin, rib, and rump cuts contain more fat than the chuck, neck, and shanks. So marked are these differences in fat that the percentages of all the constituents except the total dry substance, calculated on the fresh basis vary inversely as the percentage of fat. If the influence of the fat be eliminated by calculating the percentage of total dry substance on the fat-free basis, it is found that the leaner cuts are not clearly distinguished from one another.

PERCENTAGES OF TOTAL AND SOLUBLE PROTEIN IN THE BONELESS MEAT OF THE WHOLESALE CUTS

Total Protein.—The term protein as used here refers to the percentage of *protein* nitrogen multiplied by the factor 6.25. As already stated, protein is the essential constituent of lean meat. It consists largely of albumin compounds which serve as muscle-building material in the human body. The protein dissolved out by water at room temperature, that is, water-soluble protein, is thought to be more easily and quickly digested and hence more available to the body than the water-insoluble protein. Since beef is used chiefly for the lean meat it contains, the economic significance of the data given in Table 7 is readily apparent.

The curves of the total and soluble protein are given in Fig. 7. The order of the cuts for the two forms of protein is the inverse of that for the dry substance and fat; i.e., the shanks, clod, and round contain the highest amounts, and the flank, plate, and rib the lowest. Since a high percentage of water indicates a low percentage of fat, it naturally accompanies a large percentage of lean meat. Consequently the curve indicates that a relatively large percentage of protein is contained in the cheaper cuts of beef, while

TABLE 7.—PERCENTAGES OF WATER-SOLUBLE, INSOLUBLE, AND TOTAL PROTEIN IN THE BONELESS MEAT OF THE WHOLESALE CUTS

Wholesale cuts	Soluble	Insoluble	Total
Fore shank	1.42	15.56	16.98
Clod	1.81	14.88	16.69
Round	2.08	14.42	16.50
Hind shank	1.59	14.67	16.26
Neck	1.65	13.94	15.59
Chuck	1.47	13.40	14.87
Loin	1.37	11.59	12.96
Rump	1.26	11.30	12.56
Rib	1.20	11.12	12.32
Plate	.83	9.76	10.59
Flank	.66	8.78	9.44

the high-priced cuts, the rib and loin, are intermediate. Thus the most essential food constituent of beef is seen to vary in the different cuts quite independently of market prices.

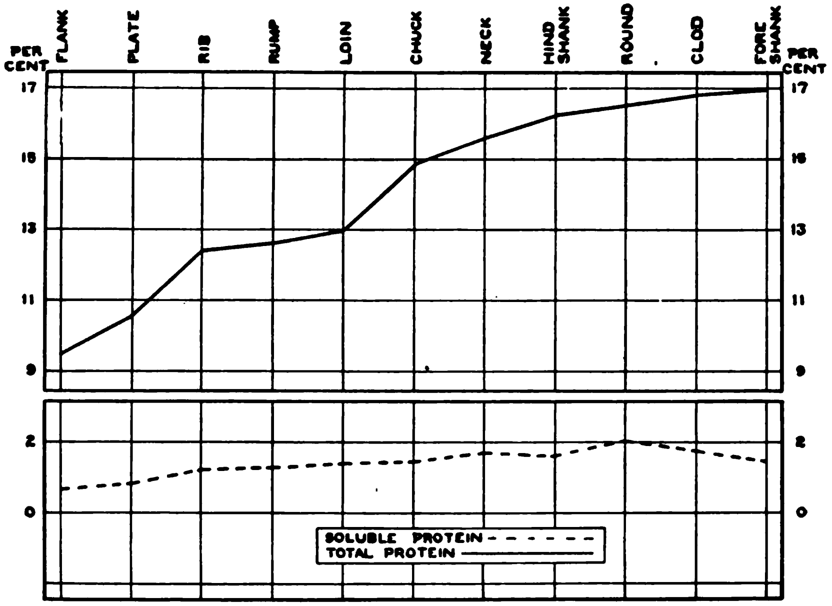

FIG. 7. PERCENTAGES OF TOTAL AND SOLUBLE PROTEIN IN THE BONELESS MEAT OF THE WHOLESALE CUTS.

The relationship between the water, fat, and total protein content of the eleven wholesale cuts is shown in Fig. 8. The curve representing the distribution of the percentages of total protein in the boneless meat rises continuously from the flank to the fore shank, being approximately the same as the curve representing the percentages of dry substance other than fat.

When figured on the dry basis the curve shows that the percentage of protein increases much more rapidly from the flank to the fore shank, due to the fact that the shanks, clod, round, and neck contain more lean and less fat, and also to the fact that lean is higher in water. If the fat be eliminated from consideration by calculating the protein on the fat-free basis, the eleven cuts are not markedly distinguished from one another, as the curve in the diagram shows. Here the curve is nearly a straight line, again showing that the market prices have no relation to the nutritive value of the cuts.

From the data available it would seem that the most expensive cuts of meat, the rib and the loin, occupy an intermediate position as to their protein content with respect to the eleven cuts of beef. This statement applies when the data are presented on either the fresh or the water-free basis, but not on the fat-free basis. In this last case there is little or no difference between any of the cuts.

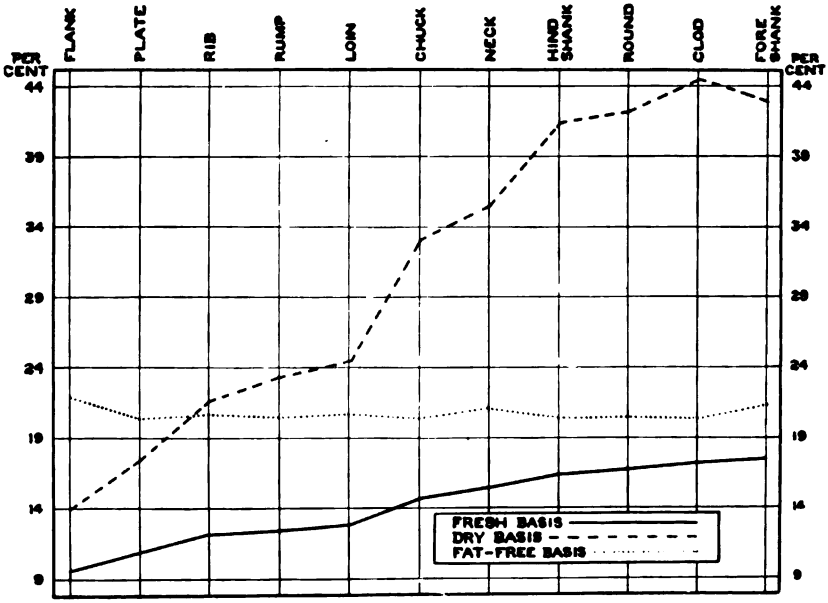

FIG. 8. PERCENTAGE OF TOTAL PROTEIN IN THE BONELESS MEAT OF THE WHOLESALE CUTS.

Soluble Protein.—On an average about one-tenth of the total protein of beef is soluble in water. The data given in Table 7, page 153, show the relative proportions of soluble protein in the various cuts. In Fig. 7, page 153, the distribution of soluble protein is shown. The percentage values for the individual cuts arrange themselves in approximately the same order as the percentages of total protein. The most significant difference in the two cases is the position of the round cut, which is third in relative value as regards total protein and first as regards soluble protein. The percentages of soluble protein range from 0.66 in the flank to 2.08 in the round. These differences also appear to be largely due to the fat content of the cuts. When the data are calculated to the fat-free basis, it is of interest to note that the arrangement of the cuts then conforms more nearly to the current market prices

PERCENTAGES OF ORGANIC EXTRACTIVES AND ASH IN THE BONELESS MEAT OF THE WHOLESALE CUTS OF BEEF

Organic Extractives.—The organic extractives of meat consist of certain water-soluble compounds. They aid in giving cooked meat its flavor. They also serve in part as stimuli to several of the glands of the digestive tract. They are increased to some extent during the ripening of meats. The nitrogenous form of extractives is made up mostly of creatin and purine bodies. The non-nitrogenous form is composed chiefly of lactic acid and glycogen. The organic extractives form the essential ingredient of beef extract, and, altho possessing only slight food value, their influence on the palatability of meat undoubtedly renders them of considerable nutritive importance.

The data given in Table 8 show that the various cuts rank in practically the same order with regard to organic extractives as to

TABLE 8.—PERCENTAGES OF ORGANIC EXTRACTIVES AND ASH IN THE BONELESS MEAT OF THE WHOLESALE CUTS

Wholesale cuts	Organic extractives			Ash		
	Nitrogenous	Non-nitrogenous	Total	Soluble	Insoluble	Total
Round	.94	1.11	2.05	.76	.11	.87
Clod	.94	1.12	1.96	.71	.14	85
Fore shank	.74	.99	1.73	.65	.18	.83
Hind shank	.75	.92	1.67	.64	.17	.81
Chuck	.78	.90	1.68	.66	.12	.78
Neck	.70	.84	1.54	.53	.14	.75
Rump	.63	.91	1.54	.53	.11	.64
Loin	.69	.88	1.57	.54	.10	64
Rib	.60	.75	1.35	.50	.12	.62
Plate	.46	.62	1.08	.38	.13	.51
Flank	.34	.42	.76	.30	.10	.40

protein. Comparing these data with those in the preceding table (No. 7) a rather close correlation is observed between the amounts of protein and organic extractives, indicating again that the leaner cuts contain larger proportions of organic extractives. Altho, so far as these figures indicate, no relation exists between the market prices and the flavor of the various cuts, it is interesting to note that the cheap cuts contain considerably larger percentages of flavoring matter, as measured by the percentages of organic extractives and soluble ash, than do several of the high-priced cuts. The proportions of nitrogenous and non-nitrogenous organic extractives are similar in the different cuts, the average ratio being about 1 to 1.25.

In Fig. 9 the data for the total and the nitrogenous organic extractives are represented by curves showing the relative distribution of the two forms among the eleven cuts of beef. In general, the two curves run in the same direction; that is, the percentage values increase in both cases from the flank to the round cuts. The chief irregularity is in the fore shank, where the percentage of nitrogenous extractives seems to drop, giving the chuck cut a higher value. The more expensive cuts, the rib and the loin, occupy an intermediate position, while the round, clod, and chuck are near the top of the curve.

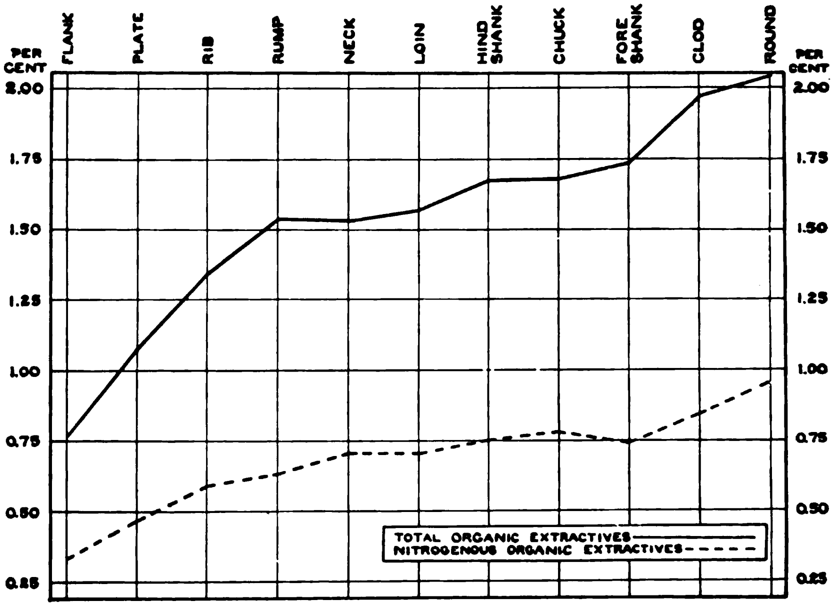

FIG. 9. PERCENTAGES OF TOTAL AND NITROGENOUS ORGANIC EXTRACTIVES IN BONELESS MEAT OF THE WHOLESALE CUTS.

Ash.—Ash, or mineral matter, is the residue that remains after cautiously burning the sample of meat until all the organic matter has been driven off. It is made up chiefly of the chlorids and phosphates of potassium, sodium, calcium, and magnesium. These contribute to the structure of bone and other body tissues, aid in the digestive functions, and increase the palatability of cooked meats.

In Table 8 the percentage values for the soluble, insoluble, and total ash are given. The soluble ash forms from 70 to 87 percent of the total. The percentage values for the total ash are about one-half those for the total organic extractives and about the same as those for the nitrogenous extractives. The soluble and total ash data are higher in the cheaper cuts.

In Fig. 10 the relative distribution of the total and the soluble ash is shown. There is a close correlation between the two curves. The main exception in the soluble ash lies in the chuck cut. To give a continuously rising curve the chuck cut should interchange places with the fore shank. Here, as in the case of the organic extractives, the rib and loin cuts occupy a place on the curve below the average value, being third and fourth respectively from the flank, between the plate and rump cuts. The chuck, shanks, clod, and round cuts are nearer the top.

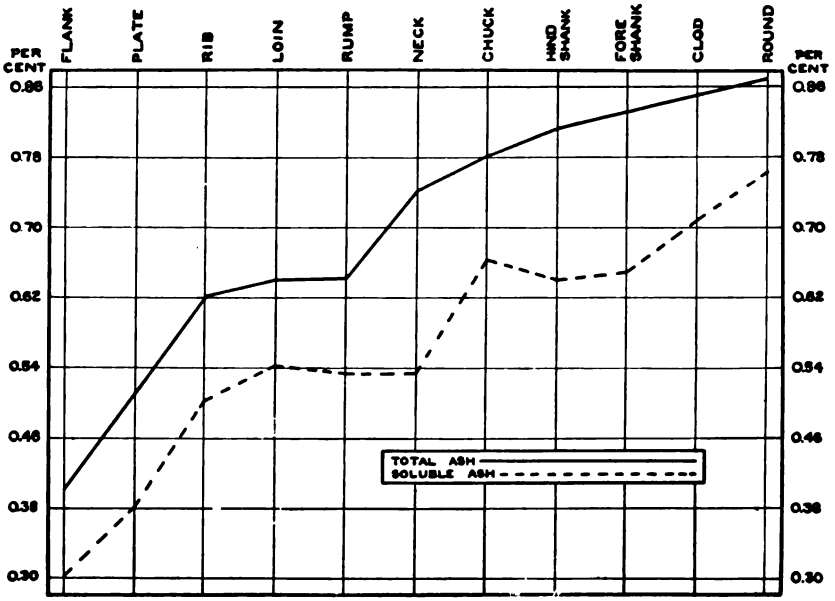

FIG. 10. PERCENTAGES OF TOTAL AND SOLUBLE ASH IN THE BONELESS MEAT OF THE WHOLESALE CUTS.

These facts are of further interest when we consider that while it is known that some of the mineral constituents of meat contribute to its palatability, it is probable that the water-soluble constituents are the most active. The percentage of soluble ash in the edible meat of the different cuts of beef should therefore be some indication of the relative degree of palatability. The curve for the soluble ash calculated on the fresh basis does not, however, distinguish the cheaper from the dearer cuts of beef. If these data be calculated to the fat-free basis, the tendency then seems to be toward making the different cuts more nearly alike; thus, the round contains 0.95 percent soluble ash and the flank 0.70 percent, while on the fresh basis the range for these cuts is 0.76 and 0.30 percent respectively.

In the same way, when the total ash is calculated to the fat-free basis the differences between the minimum and maximum percentages are much less. Thus, the round has the maximum percentage of 1.08 and the flank the minimum of 0.93.

Phosphorus.—In view of the important functions of phosphorus in animal nutrition, as indicated by recent investigations, a comparison of the forms and amounts as they occur in the various cuts is of interest. The data in the following table show that the percentages of total phosphorus vary from 0.077 in the flank to 0.184 in the round. Thus the various cuts rank in substantially the same order with respect to phosphorus and ash content. Phosphorus, like total mineral matter, is most abundant in the leaner cuts of beef, and vice versa; and its amounts are entirely independent of current market prices of the various cuts.

Table 9.—Percentages of Soluble and Insoluble Phosphorus in the Boneless Meat of Each Cut

Wholesale cuts	Soluble			Insoluble	Total
	Inorganic	Organic	Total		
Round	.093	.032	.125	.059	.184
Clod	.094	.033	.127	.046	.173
Hind shank	.085	.024	.109	.052	.161
Chuck	.091	.015	.106	.052	.158
Neck	.085	.013	.098	.050	.148
Fore shank	.092	.016	.108	.033	.141
Loin	.072	.017	.089	.053	.142
Rump	.062	.022	.084	051	.135
Rib	.065	.019	.087	.043	.130
Plate	.050	.015	.065	.039	.104
Flank	.048	.006	.054	.023	.077

The amounts of soluble phosphorus are, in general, about twice as great as those of insoluble phosphorus, and the different cuts stand in approximately the same order with regard to the soluble and insoluble forms as with respect to the total. The exceptions to this rule do not appear to follow any regular order. The same is true of the inorganic and the organic forms of soluble phosphorus, as indicated by the first and second columns of the table.

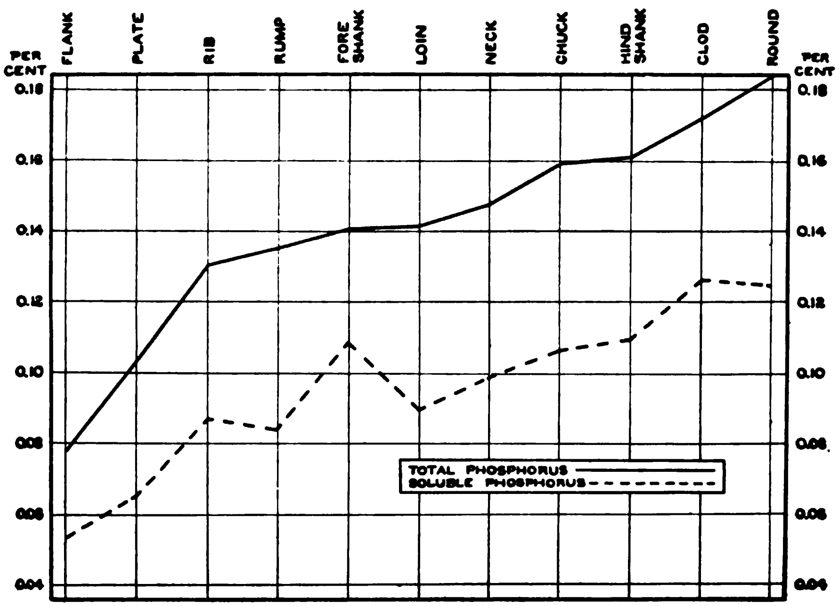

FIG. 11. PERCENTAGES OF TOTAL AND SOLUBLE PHOSPHORUS IN THE BONELESS MEAT OF THE WHOLESALE CUTS.

The above diagram (Fig. 11) shows the distribution of the total and the soluble phosphorus in the eleven wholesale cuts. From these curves it is apparent that the prices of the various cuts of beef are independent of their phosphorus content either total or soluble.

RELATIVE FUEL VALUE OF THE BONELESS MEAT OF THE WHOLESALE CUTS

As stated previously, fat, which is one of the chief food nutrients of meat, either is deposited in the body as such, or else yields energy, i.e., it produces heat and thus has fuel value. Protein, the other chief food nutrient of meat, may be used in the body not only for the formation of muscular tissue but also for the production of energy.

It therefore will be of interest to compare the fuel value of the fat and protein in the different cuts of beef, and also to compare the total fuel value of the cuts. It has been found experimentally that a gram[1] of fat when burned will yield 9.45 calories[2] of heat and that a gram of protein will produce 4.35 calories.[3]

If then the composition of the meat is known, the fuel value can be calculated by means of the above factors. In the following table these values are given for each of the eleven wholesale cuts and for the percentage distribution of the calories between the fat and protein. In order to make the relative comparison of the cuts more direct, the amounts of boneless meat necessary to furnish 1000 calories have also been calculated.

TABLE 10.—RELATIVE FUEL VALUE OF THE BONELESS MEAT OF THE WHOLESALE CUTS

Wholesale cuts	Calories[4] furnished by 100 grams of boneless meat			Percentage distribution of calories		Pounds of boneless meat required to furnish 1000 calories
	Fat x9	Protein x4	Total	In fat	In protein	
Flank	514.4	40.5	554.9	92.7	7.3	.40
Plate	437.1	46.0	483.1	90.5	9.5	.46
Rib	365.6	54.1	419.7	87.1	12.9	.52
Rump	350.5	55.3	405.8	86.4	13.6	.54
Loin	339.4	57.4	396.8	85.5	14.5	.56
Chuck	247.9	65.8	313.7	79.0	21.0	.70
Neck	235.1	67.9	303.0	77.6	22.4	.73
Hind shank	186.9	71.0	257.9	72.5	27.5	86
Fore shank	179.8	73.9	253.7	70.9	29.1	.87
Round	176.9	73.6	250.5	70.6	29.4	.88
Clod	161.6	73.5	235.1	68.7	31.3	.94

In the above table the data were calculated as follows: The percentages of fat in the various cuts were obtained from Table 6, page 149. Those for the protein, as previously referred to in Table 7, page 153, are not applicable. In this case the total nitrogen content of the meat was multiplied by 6.25 to obtain crude protein, that being the value usually assigned in calculating the energy of protein. The percentage of fat was multiplied by 9, and the percentage of protein by 4, and the two results added to give the total calories in the cut. Thus, in the flank, the percentage of fat is 57.16, and that of protein 10.12. Therefore, one hundred grams of the meat will yield 514.4 calories from the fat (57.16 x 9) and 40.5 calories from the protein (10.12 x 4), making a total of 554.9 calories.

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[1] 453.59 grams equal one pound.

[2] A large calorie is the amount of heat required to raise the temperature of one kilogram of water one degree Centigrade.

[3] 95 percent of the energy of fat and 92 percent of that of protein are available in the case of man. Hence, the approximate fuel values of fat and protein are 9=(9.45x95) and 4=(4.35x92) calories per gram respectively.

[4] Large calorie.

The data in the table show, as would be expected, the high calorific value of those cuts which have a high percentage of fat. Thus, in the third column the flank, plate, rib, rump and loin cuts are from one and one-half to two times as great in fuel value as the shanks, round, and clod. These differences are shown in column 1, also, where the extremes are 514.4 calories for the flank and 161.6 calories for the clod. In column 4 the percentage distribution of calories in the fat is shown to range from 68.7 in the clod to 92.7 in the flank cut. In the rib and the loin cuts the fat furnishes 87.1 and 85.5 percent respectively of the fuel value, while in the shanks, round, and clod cuts the fat makes up about 69 percent. The protein, on the other hand, supplies from 7.3 percent of the total calorific value in the flank cut to 31.3 percent in the clod cut. In order to make a more direct comparison of the different cuts, the amount of boneless meat required to furnish 1000 calories has been calculated. These data, in the last column, show that the flank and plate cuts require the smallest amounts, 0.40 and 0.46 pounds respectively. The rib, rump, and loin cuts come next, averaging 0.54 pounds. The chuck and neck cuts follow with values averaging 0.71 pounds. The shanks and round run about the same, varying from 0.86 pounds for the hind shank to 0.88 pounds for the round and averaging 0.87 pounds for all three cuts. The clod cut requires the largest amount of boneless meat, 0.94 pounds, to furnish 1000 calories.

RELATIVE ECONOMY OF THE NUTRIENTS OF THE BONELESS MEAT OF THE WHOLESALE CUTS AT CURRENT MARKET PRICES

From the discussion of the distribution of the various nutrients in the eleven wholesale cuts of beef, it was seen that some of the cheaper cuts, such as the round, clod, chuck, and shanks, contained just as high or higher percentages of protein, organic extractives, and mineral matter as the more expensive cuts. The main difference between the cuts was in the fat content. Since meat is bought chiefly for the protein it contains and secondarily for fat, it will be of interest to compare the net cost of a given amount of protein from each cut, and also the cost of the meat from each cut needed to supply a definite number of calories. These data are given in Table 11.

TABLE 11.—COST OF MEAT REQUIRED TO FURNISH ONE POUND OF PROTEIN AND 1000 CALORIES FROM WHOLESALE CUTS AT MARKET PRICES

Wholesale cuts	Retail[1] price per pound, cents	Boneless meat in the cut, percent	Cost of pound boneless meat in cut, cents	Cost of pound protein in cut, cents	Cost of 1000 calories in cut, cents
Fore shank	5	59.56	8.4	50	7
Hind shank	5	48.84	10.2	63	9
Neck	6	84.31	7.1	46	5
Flank	8	99.44	8.0	85	3
Plate	8	91.23	8.7	82	4
Clod	10	95.18	10.5	63	10
Chuck	11	87.99	12.5	84	9
Rump	12	79.85	15.0	119	8
Round	15	90.39	16.6	101	15
Rib	18	85.56	21.0	171	11
Loin	22	90.23	24.4	188	14

[1] Average prices calculated from the retail prices given in Table 19, page 171.

The calculations are based upon the prices given in the first column. From the percentage of boneless meat, the retail cost per pound of the boneless meat in the cuts was obtained. Knowing the percentage of protein in the boneless meat (Table 7), and the percentage of boneless meat in the cut, the cost per pound of protein was calculated. The cheapest cuts for protein are the neck, shanks and clod. The neck furnishes a pound of protein for 46 cents; the fore shank for 50 cents; the hind shank for 63 cents, and the clod for 63 cents. The loin, rib, rump, and round furnish a pound of protein for the most money: the loin for $1.88; the rib for $1.71; the rump for $1.19, and the round for $1.01. The flank, plate, and chuck cuts supply a pound of protein for 85, 82, and 84 cents respectively. With reference to the cost of protein, the most economical cuts which are suitable for general use are the clod, plate, and chuck, in the order named.

From the cost per pound of the boneless meat and from the amount of boneless meat required to furnish 1000 calories (Table 10), it is possible to determine the cost of the meat necessary to supply the same fuel value for each cut. These results are given in the last column. They indicate that the eleven cuts can be grouped into four classes: first, the flank, plate, and neck, costing 3, 4 and 5 cents, respectively, per 1000 calories; second, the fore shank and the rump, costing 7 and 8 cents respectively; third, the hind shank, chuck, clod and rib, costing 9, 9, 10 and 11 cents respectively; and fourth, the loin and round, costing 14 and 15 cents respectively. Considering their adaptability for general use, the most economical cuts in terms of fuel value are the plate, rump, chuck, and clod.

It will be of interest to see which cuts of beef are the most economical for protein and fuel value combined. In the above discussion the relative order of the cuts is not the same in the two cases. The neck, shank, and plate are among the cheapest cuts in both instances, while the round, rib, and loin are the most expensive. From the standpoint of both protein and energy value, the most economical cuts adapted to general use are the clod, chuck, and plate, in the order named.

It should of course be borne in mind that some of these cheaper cuts are less tender and therefore more difficult to prepare for use than steaks and roasts. Nevertheless, in view of the fact that there is little difference between the various cuts as to their percentages of organic extractives and ash (the nutrients which assist in giving flavor and palatability to cooked meat), and since the digestibility[1] of protein is independent of the kind or cut of meat and of the method of cooking (broiling, roasting or boiling), the cheaper cuts, in general, may be said to compare favorably with the higher-priced ones, even in regard to flavor and palatability. Considering the further fact that they furnish more protein and fuel value per unit of meat, these cuts are evidently more economical sources of food nutrients.

RETAIL CUTS

The wholesale cuts (Fig. 3, page 143) were further divided into the various retail cuts that are commonly made in meat markets. Fig. 12 represents the manner of cutting and the location of the different cuts. The weight of each, taken immediately upon cutting, is recorded in the appendix (Tables 10-23). The cuts that required trimming to remove surplus fat and bone were so trimmed in accordance with meat-market custom, the trimmings and the trimmed cut being weighed in each case (Tables 24-38, Appendix). Each retail cut was then carefully separated by means of boning knives into lean, visible fat, and bone, and the weight of each portion recorded[2] (Tables 24-32, Appendix). In the case of trimmed cuts the different constituents of the trimmings were likewise separated and weighed (Tables 33-38, Appendix).

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[1] Bulletin 162, U. S. Dept. Agr., O.E.S. (1903), by Grindley and Emmett; also Bulletin 193 by Grindley, Mojonnier, and Porter (1907).

[2] In the case of Steer No. 1 the weight of bone in each cut was determined by difference. In Nos. 2 and 3 the bone was weighed separately, which accounts for the slight amounts of loss and error recorded in those instances and in the general averages.

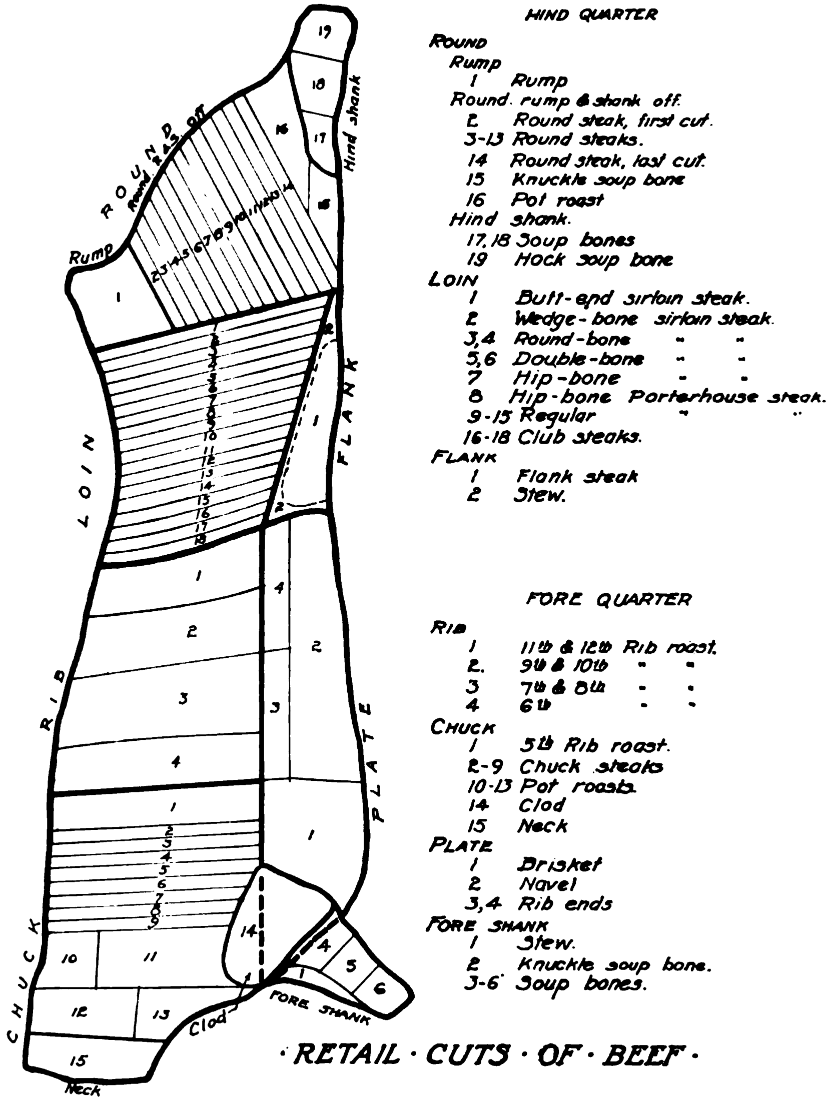

FIG. 12. METHOD OF CUTTING THE THREE SIDES, SHOWING RETAIL CUTS.

In order to compare the various retail cuts as to their relative amounts of lean, fat, and bone, the weights of these constituents have been reduced to percentages; and in the interest of brevity, average percentages of the respective constituents yielded by corresponding cuts from the three sides of beef are made the basis of the following summary and discussion. Tables 12 to 18, inclusive, represent untrimmed cuts. Further differences brought about by trimming will be briefly summarized in connection with the discussion of the various cuts, and will be considered more specifically in the following section with reference to the question of relative economy.

LOIN

With reference to the proportions of lean and fat in the cuts of the loin (Table 12) it will be noticed that the sirloin steaks are in general leaner than the porterhouse and club steaks, and that all of the latter are comparatively similar in this respect. The percentage of bone varies considerably; and it is apparent that the double-bone, hip-bone and club steaks have relatively more bone than the remainder of the loin, owing to portions of the hip-bone contained in the former and of the thirteenth rib in the latter. It is evident from these figures that while porterhouse steaks command a higher price than sirloin, they actually contain a smaller proportion of lean meat and more excess fat. See Figs. 13 to 28.

TABLE 12.—PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS

Retail loin cuts	Lean	Fat	Bone	Total
1. Sirloin steak (butt-end)	70.46	23.32	5.67	99.45
2. Sirloin steak (wedge-bone)	69.82	23.27	6.40	99.49
3. Sirloin steak (round-bone)	65.71	28.17	5.37	99.25
4. Sirloin steak (round-bone)	61.43	29.18	8.94	99.55
5. Sirloin steak (double-bone)	59.01	26.55	13.84	99.40
6. Sirloin steak (double-bone)[1]	68.69	17.72	12.49	98.90
7. Sirloin steak (hip-bone)[2]	50.11	31.73	16.05	97.89
8. Porterhouse steak (hip-bone)	54.39	32.88	11.51	98.78
9. Porterhouse steak	53.78	39.22	5.80	98.80
10. Porterhouse steak	53.56	39.24	6.64	99.44
11. Porterhouse steak	59.41	32.93	6.46	98.80
12. Porterhouse steak	56.22	35.96	6.84	99.02
13. Porterhouse steak	55.49	35.41	8.23	99.13
14. Porterhouse steak	54.83	34.33	9.52	98.68
15. Porterhouse steak	50.04	41.44	7.77	99.25
16. Club steak	55.38	36.35	7.89	99.82
17. Club steak	55.33	32.93	12.80	99.06
18. Club steak	54.10	33.81	11.19	99.10
19. Trimmings (wholesale)[3]	9.79	90.21	0	100.00
Entire loin	58.53	31.75	8.89	99.17

Trimming the retail cuts of the loin reduces their weight about 12 percent. (Tables 33 and 34, Appendix). The relative amount of trimmings is similar in the three classes of steaks; but those from the porterhouse cuts contain the largest proportion of fat, while the sirloin trimmings contain the most bone. The trimmings from the various loin steaks consist of about 80 percent visible fat, 18 percent bone, and 2 percent lean.

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[1] This cut was made from the loins of Steers Nos. 1 and 2 only.
[2] This cut was made from the loins of Steers Nos. 2 and 3 only.
[3] This cut was made from the loin of Steer No. 3 only.

RIB

Table 13 shows that the first cut of the rib contains the smallest proportion of lean meat, while the last cut, or sixth rib roast, is the leanest. The reverse is true of the percentage of fat. In terms of gross meat, i.e., lean and fat combined, the first roast is most valuable and the third cut least; moreover, the greater degree of tenderness and general quality in the first cut makes it the most popular and therefore the highest-priced of the rib roasts. Since, however, beef roasts are valuable primarily for the lean meat they contain, it is evident that the sixth rib is the most economical at a given price. See Figs. 29 to 32.

TABLE 13.—PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS

Retail rib cuts	Lean	Fat	Bone	Total
1. Roast (11th and 12th ribs)	49.44	37.74	12.41	99.59
2. Roast (9th and 10th ribs)	54.26	31.41	13.97	99.64
3. Roast (7th and 8th ribs)	56.00	27.81	15.79	99.60
4. Roast (6th rib)	61.43	23.72	14.27	99.42
Entire rib	55.21	30.17	14.18	99.56

ROUND

Comparing the retail cuts of the round (Table 14) it is found that the rump roast is made up of about one-half lean and one-third visible fat; the round steaks, from 73 to 85 percent lean and 9 to 22 percent visible fat; and the hind-shank soup bones are exceedingly variable in proportions of lean, visible fat, and bone. The various steaks are somewhat similar in percentage of lean meat, but cuts Nos. 5 to 12 contain noticeably less bone and more visible fat than those nearer the extremities of the round. The round pot roast, which is usually a boneless cut, contains a larger proportion of lean meat than any other cut of the round. The knuckle and hock soup bones consist very largely of bone, while the remaining soup-bone cuts have considerable percentages of lean. See Figs. 33 to 45.

Results of trimming the various round cuts are shown in Tables 35 and 36, Appendix. Rump roasts are thus reduced in weight by

TABLE 14.—PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS

Retail round cuts	Lean	Fat	Bone	Total
1. Rump roast	48.62	31.13	19.81	99.57
2. Round steak (first cut)	74.16	13.57	11.26	98.99
3. Round steak	76.99	13.19	9.02	99.20
4. Round steak	84.47	9.71	5.13	99.31
5. Round steak	83.12	12.94	3.33	99.39
6. Round steak	81.84	14.36	2.64	98.84
7. Round steak	78.79	17.63	2.52	98.94
8. Round steak	77.53	19.61	2.62	99.76
9. Round steak[1]	81.85	15.93	2.22	100.00
10. Round steak[1]	78.15	19.33	2.52	100.00
11. Round steak[1]	74.90	21.96	3.14	100.00
12. Round steak	73.73	21.95	3.77	99.45
13. Round steak[1]	81.02	14.36	4.62	100.00
14. Round steak	75.05	16.63	7.31	98.99
15. Knuckle soup bone	19.00	21.78	58.36	99.14
16. Pot roast	85.43	13.38	0.87	99.68
17. Shank soup bone	40.13	11.37	47.62	99.12
18. Shank soup bone	66.72	12.35	20.19	99.46
19. Shank soup bone (hock)	8.08	10.36	80.86	99.30
Entire round	64.61	18.03	16.63	99.27

[1] This cut was made from the round of Steer No. 1 only.

about one-third; and the rump trimmings are composed of about 56 percent bone, 30 percent fat and 14 percent lean. Fat only is trimmed from the round steaks, as a rule, and they are reduced only about 5 percent in weight. The greatest proportionate amount of trimmings is taken from the first cut steak, in which case the trimmings consist principally of bone; and, in general, the fifth to the eighth cuts are trimmed more than the remaining ones.

CHUCK

The fifth rib roast, taken from the chuck (Table 15), resembles the prime rib roast in regard to proportions of meat and bone, but exceeds them in relative amount of lean, just as the adjacent sixth rib roast shows the largest percentage of lean in the prime ribs (Table 13). It is also observed that the successive chuck steaks, which are cut anterior and parallel to the fifth rib roast, tend in general toward a larger proportion of lean meat with a smaller percentage of fat and bone. Three pot roasts, cuts Nos. 10, 11, and 12, cut next to the chuck steaks, vary considerably with respect to all three constituents, Nos. 10 and 12 resembling the chuck steaks, while No. 11 has a comparatively small percentage of lean and a large percentage of fat. The stew (No. 13), taken from the lower portion of the shoulder near the brisket, is the fattest cut of

TABLE 15.—PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS

Retail chuck cuts	Lean	Fat	Bone	Total
1. Roast (5th rib)	64.07	20.78	14.65	99.50
2. Chuck steak	62.11	18.80	18.33	99.24
3. Chuck steak	66.26	22.29	10.94	99.49
4. Chuck steak	72.41	15.81	11.37	99.29
5. Chuck steak	69.91	16.60	12.50	99.01
6. Chuck steak	75.64	14.23	9.68	99.55
7. Chuck steak	82.10	6.41	10.78	99.29
8. Chuck steak	75.60	13.60	10.28	99.48
9. Chuck steak	74.76	14.57	9.85	99.18
10. Pot roast	75.89	14.44	8.89	99.22
11. Pot roast	58.45	26.53	13.94	98.92
12. Pot roast	78.06	9.07	12.66	99.79
13. Stew	60.79	33.86	5.03	99.68
14. Clod	80.39	14.62	4.69	99.70
15. Neck	60.47	22.12	16.48	99.07
Entire chuck	69.47	18.63	11.26	99.36

the chuck, and contains but little bone. The neck piece is intermediate in proportionate amounts of edible meat and waste. The clod is the most economical cut of the chuck in point of gross meat, and, with one exception, also contains the highest percentage of lean. See Figs. 46 to 60.

Retail trimmings from the chuck (Tables 37 and 38, Appendix) consist chiefly of neck scraps, these making up nearly half the total trimmings taken from the chuck of Steer No. 1 and about one-third in the case of Steer No. 2. The chuck roast and steaks are trimmed to about the same extent as the round steaks, amounting to 5 percent of their weight; the trimmings consisting largely of bone. Of the remaining cuts only No. 11 (the pot roast adjacent to the clod and knuckle) requires much trimming, the surplus in this case being chiefly fat and bone. On the average the chuck cuts are reduced in weight by about 10 percent, and the trimmings are composed of about 40 percent fat, 30 percent lean and 30 percent bone.

PLATE

The two principal divisions of the plate, viz., the brisket and the navel, are remarkably similar in proportions of lean, visible fat, and bone (Table 16). The rib ends, which are small pieces cut from the upper portion of the navel, contain relatively more bone and less lean than the remainder of the plate, but are similar to it in percentage of visible fat. The wholesale trimmings consist chiefly of surplus fat taken from the lower edge of the plate. See Figs. 61 to 64.

TABLE 16.—PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS.

Retail plate cuts	Lean	Fat	Bone	Total
1. Brisket	53.33	38.81	7.78	99.92
2. Navel	54.87	37.22	7.91	100.00
3. Rib ends	49.44	37.31	12.35	99.10
4. Rib ends	50.79	36.39	12.36	99.54
5. Wholesale trimmings	13.89	86.11	0	100.00
Entire plate	50.61	40.73	8.47	99.81

FLANK

About half the weight of the flank cut from prime cattle consists of surplus fat which must be trimmed off and sold for tallow (Table 20, Appendix). A boneless steak is then stripped off, which, in this test, consisted of about 83 percent lean and the remainder, visible fat. The rest of the flank (cut No. 1) is stewing meat containing about two parts of lean to one of visible fat. See Figs. 65 and 66.

TABLE 17.—PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS

Retail flank cuts	Lean	Fat	Bone	Total
1. Stew	64.11	34.79	.58	99.48
2. Flank steak	83.05	16.44	0	99.49
3. Trimmings (wholesale)	.37	99.63	0	100.00
Entire flank	36.30	63.18	0.25	99.73

FORE SHANK

The boneless stewing piece taken from the front of the shank (cut No. 1) contains a larger proportion of both lean and fat than the shank soup-bone cuts. Of the latter, it is seen in Table 18 that

TABLE 18.—PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS

Retail fore-shank cuts	Lean	Fat	Bone	Total
1. Stew	82.58	17.10	0	99.68
2. Soup bone (knuckle)	29.38	11.12	58.68	99.18
3. Soup bone	28.03	10.98	60.23	99.24
4. Soup bone	39.88	13.14	46.61	99.62
5. Soup bone	68.88	5.68	25.16	99.72
6. Soup bone	17.43	6.51	74.94	98.88
Entire shank	47.61	11.63	40.20	99.44

the two cuts nearest the chuck (Nos. 2 and 3) are very similar, containing small proportions of lean and much bone. In the next two cuts the percentage of lean increases and that of bone decreases. The fifth cut contains a remarkably large percentage of lean and of gross meat, while the sixth cut, containing about 75 percent of bone, has the smallest relative amount of meat. See Figs. 67 to 69.

RELATIVE ECONOMY OF THE VARIOUS RETAIL CUTS

From the proportions of lean, fat and bone in the different cuts, their relative economy at retail market prices may be determined. The net cost of lean meat is an approximate index of the relative economy of steaks and roasts, since they are purchased and used primarily for the lean they contain; but in comparing boiling, stewing, and similar meats, the cost of gross meat, or fat and lean combined, should be more largely considered, because the fat is more completely utilized, as in the case of meat loaf, hash, Hamburger and corned beef. Soup bones, being valued for flavoring matter as well as for the nutritive substance they contain, are more difficult to compare with other cuts in respect to relative economy. They vary materially, however, in proportions of edible meat and waste, and should therefore be studied in this connection.

The relative cost of lean meat in a given cut consists of the price per pound paid for the cut divided by the percentage of lean it contains; and, similarly, the cost per pound of gross meat is the market price of the cut divided by its total percentage of lean and fat meat. For example, in a steak costing 20 cents per pound and composed of 80 percent lean, 10 percent visible fat and 10 percent bone, the net cost per pound of lean is 20 cents ÷ .80, or 25 cents, and the net cost per pound of total meat is 20 cents ÷ .90 (.80 + .10), or 22.2 cents.

Retail prices of beef cuts vary widely, depending upon market prices of live cattle and carcass beef; also upon the method of cutting and trimming used, and upon local customs and conditions. Consequently, the relative economy of the different cuts varies accordingly and cannot, therefore, be expressed in fixed terms The following table is based upon prices charged for the highest grade of beef cuts in first-class city meat markets. Altho it fairly represents the relative net cost of the retail cuts under the conditions stated, the table is designed primarily to illustrate the method by which the relative economy of different cuts may be calculated for any given scale of prices.

Table 19 is based upon Tables 13, 16, 17 and 18 of the text, and, in the case of cuts that were trimmed, Tables 26, 29 and 32, Appendix. In case it is desired to compare the untrimmed cuts, then Tables 12 to 18 inclusive in the foregoing text should be used as the basis, and prices assigned accordingly.

TABLE 19.—COST OF LEAN AND OF TOTAL MEAT IN THE VARIOUS RETAIL CUTS AT MARKET PRICES

RETAIL CUTS	Diagram number (Fig. 12)	Retail price per pound of cut, cents	Cost per pound of lean meat in cut, cents	Cost per pound of lean and fat meat in cut, cents
STEAKS				
Porterhouse, hip-bone	8	25	38.6	28.9
Porterhouse, regular	10	25	40.2	27.2
Club steak	18	20	32.1	22.6
Sirloin, butt-end	1	20	25.3	20.6
Sirloin, round-bone	3	20	28.3	21.1
Sirloin, double-bone	5	20	28.7	22.7
Sirloin, hip-bone	7	20	32.3	24.2
Flank steak	1	16	19.3	16.0
Round, first cut	2	15	17.0	15.3
Round, middle cut	6	15	17.3	15.6
Round, last cut	14	15	19.3	16.0
Chuck, first cut	2	12	18.3	14.1
Chuck, last cut	9	12	15.7	13.1
ROASTS				
Prime ribs, first cut	1	20	40.5	22.9
Prime ribs, last cut	4	16	26.1	18.8
Chuck, 5th rib	1	15	22.8	17.3
Rump	1	12	19.4	12.8
BOILING AND STEWING PIECES				
Round pot roast	16	10	11.6	10.1
Shoulder clod	14	10	12.3	10.5
Shoulder pot roast	11	10	14.3	11.6
Rib ends	3	8	16.2	9.2
Brisket	1	8	15.0	8.7
Navel	2	7	12.8	7.7
Flank stew	2	7	10.9	7.1
Fore shank stew	1	7	8.5	7.0
Neck	15	6	8.5	7.0
SOUP BONES				
Round, knuckle	2	5	26.3	12.5
Hind shank, middle cut	18	5	7.5	6.3
Hind shank, hock	19	5	62.5	26.6
Fore shank, knuckle	2	5	17.2	12.5
Fore shank, middle cut	4	5	12.5	9.4
Fore shank, end	6	5	28.8	20.9

Taking the net cost of the lean meat as a basis of comparison, we learn from these data that the most expensive steaks at the prices given are the porterhouse cuts, followed by the club, sirloin, flank, round, and chuck steaks. Of the different roasts, the first-cut prime ribs are the most costly in terms of lean meat, and the rump roast is the most economical. The various boiling and stewing pieces furnish lean meat more economically at market prices than either the roasts or steaks; the rib ends and brisket being the dearer cuts of this class, while the neck and shank stews are relatively cheapest. Several of the soup bones are very economical sources of lean meat, particularly the middle cuts of both shanks; and only one of them is extremely expensive, even on this basis. In general, the wide variation between the various cuts in net cost of lean is remarkable, ranging from 7.5 cents in one of the soup bones to 40.5 cents in a prime rib roast, and up to 62.5 cents in the hock soup bone; the latter, however, being used primarily for its flavoring substance rather than for lean meat. It will be observed, also, that the market prices of the cheaper cuts correspond much more closely to their net cost of lean meat than is true of the higher-priced steaks and roasts.

The net cost per pound of gross meat, or lean and fat combined, varies much less as between the different cuts than does the net cost per pound of lean, because the proportions of total meat are more nearly uniform than the percentages of lean. The various steaks and roasts rank in substantially the same order as to relative economy on this basis as on the basis of lean meat. The rib roasts, however, are considerably more economical as compared with the porterhouse and sirloin steaks when all the edible meat is considered. The rump shows a very low cost per pound of edible meat, due to the large proportion of fat it contains; and a still further difference is noticed in the case of the rib ends, brisket, navel, flank, neck, and several of the soup-bone cuts. The stewing meats are generally the most economical sources of edible meat at these prices, while porterhouse steaks are the most expensive.

On the whole, the data clearly show that the cheaper cuts of beef are by far the most economical sources both of lean and of total edible meat, including fat and lean. It has been shown elsewhere (page 156) that no correlation exists between market prices and the proportion of flavoring substances contained in various portions of the carcass; and cooking tests indicate that the proportion of waste and shrinkage is not necessarily greater in the cheaper than in the more expensive cuts.[1] It is evident, therefore, that retail prices of beef cuts are determined chiefly by considerations other than their food value, such as tenderness, grain, color, general appearance, and convenience of cooking.

In view of these facts, Table 19 constitutes a striking illustration of the irrational standards which characterize the demand for beef, and of the consequent wide variation in prices between retail beef cuts from different portions of the carcass. A careful study of these data, together with Fig. 12 and the following photographs of all the cuts from Steer No. 3, will enable the reader to purchase the various retail cuts of choice beef with respect to the relative amounts of edible meat and waste they contain, and thus to profit by the prevailing discrepancies in market prices.

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[1] Bulletin 162, U. S. Dept. Agr., O.E.S. (1903), by Grindley and Emmett.

CONCLUSIONS

1. The relative efficiency of different types of cattle or systems of production cannot be accurately compared without considering the adaptability of the beef to the purpose for which it is used.

2. Those who would buy meats most intelligently must know the nature of the different cuts, especially with reference to the proportions of lean meat, fat, and bone they contain and the food value of edible meat cut from different parts of the carcass.

3. It is highly essential to the entire beef-cattle industry, on the one hand, and the economic welfare of the beef-eating public, on the other, that a more intelligent understanding of the different cuts of meat be acquired by consumers generally.

SLAUGHTER TESTS

4. *Dressed Beef.*—The proportion of chilled dressed beef to live weight yielded by the two choice steers used in these investigations was 60.36 and 60.88 percent respectively, and that of the prime steer was 63.97 percent. Page 140

5. *Internal Fat.*—The killing fats yielded by the three steers were 5.15, 5.97, and 4.71 percent respectively (live weight basis). Notwithstanding the high condition of Steer No. 3, this animal yielded the lowest percentage of internal fat, indicating marked efficiency for beef production. Page 140

6. *Hides.*—The yields of hides were 7.48, 6.51, and 6.43 percent respectively (live weight basis). Page 140

7. *Offal.*—Steer No. 1 yielded the largest proportion of head, feet, tail, tongue, heart, liver, lungs, trachea, paunch, intestines, and spleen. Steer No. 3 had the smallest relative weight of offal. Page 140

WHOLESALE CUTS

8. *Percent Yield.*—Average yields of straight cuts were: loins, 16.76 percent; ribs, 9.77; rounds, 21.78; chucks, 21.89; plates, 15.63; flanks, 5.15; fore shanks, 4.97; and kidney suet, 4.06. Page 142

6. *Lean, Fat, and Bone.*—The proportion of lean in the various straight wholesale cuts varied from about one-third in the flank to about two-thirds in the chuck; the extreme percentages of visible fat were 11 percent in the shank and 63 percent in the

flank; and the percentage of bone ranged from practically nothing in the flank to 40 percent in the shank. In general, the cuts containing a large percentage of lean had a small percentage of visible fat, and vice versa, while the relative weight of bone was more variable. Page 145

The relative amounts of lean, visible fat, and bone in the hind and fore quarters were as follows: hind quarter, 54.42 percent lean, 34.55 percent visible fat, and 10.71 percent bone; fore quarter, 59.12 percent lean, 26.69 percent visible fat, and 13.73 percent bone. Page 145

The three sides of beef used in this experiment averaged about 57 percent lean meat, 30 percent visible fat, and 12 percent bone. Page 145

7. *Relative Economy.*—The net cost per pound of lean meat is, in general, greatest in the cuts which command the highest prices, and vice versa. Further, the more expensive the cut, the greater the cost per pound of visible fat and lean combined. Thus the relative food values of the various cuts do not correspond to their market prices, the cheaper cuts being by far the more economical sources both of lean and of total edible meat. Page 147

NUTRITIVE VALUE OF THE BONELESS MEAT OF THE VARIOUS WHOLESALE CUTS

8. *Dry Substance.*—The average water content of the edible meat of the wholesale cuts varied from 32 percent in the flank to 63 percent in the clod; and consequently the total dry substance ranged from 37 percent in the clod to 68 percent in the flank. The percentage of soluble dry substance varied inversely as that of total dry substance in the various cuts. Page 150

9. *Fat.*—In general, the various wholesale cuts stood in the same order with respect to the percentages of both total fat and total dry substance contained in the edible meat; in other words, the higher the percentage of fat, the lower the percentage of water. The total fat content varied from 18 percent in the clod to 57 percent in the flank. Page 151

10. *Protein.*—Protein, the most essential food constituent of beef, varied in the different cuts inversely as the dry substance and fat. The maximum percentage, 16.98, was found in the shank; and the minimum, 9.44, in the flank. Soluble protein varied from 0.66 to 2.08 percent, and was, in general, proportional to total protein in the different cuts. If calculated to the fat-free basis, the eleven wholesale cuts correspond closely in percentages of protein, ranging only from 20 to 22 percent. Page 152

11. *Organic Extractives.*—These varied from 0.76 percent in the flank to 2.06 percent in the round. The ratio of nitrogenous

to non-nitrogenous extractives in the various cuts was similar. A rather close correlation existed between the relative amounts of protein and those of organic extractives, indicating that the leaner cuts contained larger proportions of organic extractives than did those rich in fat. No relation seemed to exist between the market prices and the flavoring constituents of the various cuts. The high-priced cuts (the loin and rib) contained considerably smaller percentages of organic extractives than did several of the cheaper cuts. These statements do not take into account the influence of marbling upon flavor of the different cuts. Page 155

12. *Ash.*—The percentage of ash varied from 0.40 in the flank to 0.87 in the round. The soluble ash formed from 70 to 87 percent of the total. There was a tendency for both the soluble and the total ash to be higher in the cheaper cuts, and since these, especially the soluble form, contribute to the palatability of meat, there would seem to be no relation between market prices and the palatability of different cuts. Page 157

13. *Phosphorus.*—Phosphorus, like total mineral matter, was most abundant in the leaner cuts of beef, and vice versa, and its relative amounts were therefore independent of current market prices of the various cuts. The percentage of phosphorus in the meat varied from 0.077 in the flank to 0.184 in the round. Page 158

14. *Fuel Value.*—The relative fuel value is a significant factor in considering the nutritive value of meat. It depends primarily on the fat content, the fatter cuts of meat being highest in fuel value. One hundred grams of meat from the flank furnished the maximum calories, 554.9, and one hundred grams from the clod furnished the minimum number, 235.1. It required from 0.40 pound of boneless meat in the flank to 0.94 pouna in the clod to furnish 1000 calories. Page 159

15. *Relative Economy.*—There seems to be no relation between market prices and the percentages of fat, protein, extractives, and ash. The cheaper cuts appear to be as valuable and in some cases actually more so than the higher-priced cuts from the standpoint of protein and of energy. These statements do not take into account the factors of tenderness nor the influence the degree of fatness may have upon the palatability of cooked meat. In purchasing meat for protein primarily, the neck, shanks and clod are the most economical cuts; the plate, chuck, flank and round follow; with the rump, rib, and loin as the most expensive. From the standpoint of fuel value, the flank, plate, neck, and shank cuts are the cheapest, while the rib, loin, and round are the most expensive. Considering both factors, protein and fuel value, and along with

these the adaptability of the meat for general use the clod, chuck, and plate are the most economical cuts at the retail prices given. Page 161

RETAIL CUTS

16. *Loin Cuts.*—Loin steaks averaged 59 percent lean, 32 percent visible fat, and 9 percent bone. Sirloin steaks in general contained a greater proportion of lean and smaller proportion of fat than porterhouse and club steaks. Page 165

17. *Rib Cuts.*—Rib roasts contained, on the average, 55 percent lean, 30 percent visible fat, and 15 percent bone. The greatest percentage of lean was found in the sixth rib roast, and the smallest in the eleventh and twelfth rib cut. Page 166

18. *Round Cuts.*—The various cuts made from the round averaged 65 percent lean, 18 percent visible fat, and 17 percent bone. Round steaks contained 74 to 84 percent lean; the rump roast, 49 percent; round pot roast, 85 percent; and soup bones, 8 to 66 percent. The maximum percentage of fat was found in the rump roast, and the maximum percentage of bone, in the hock soup bone. Page 166

19. *Chuck Cuts.*—These contained an average of 69 percent lean, 19 percent fat, and 11 percent bone. Chuck steaks varied from 62 to 82 percent lean, and from 6 to 22 percent fat. The shoulder clod contained 80 percent lean and only 5 percent bone. Relatively more lean and less fat were found in the chuck rib roast than in those cut from the prime rib. Page 167

20. *Plate Cuts.*—The brisket, navel, and rib ends averaged 51 percent lean, 41 percent fat, and 8 percent bone. The brisket and navel were similar in proportions of the different constituents, but the rib ends were slightly higher in percentage of bone and lower in lean. Page 168

21. *Flank Cuts.*—The flank steak contained 83 percent lean and 16 percent fat; and the flank stew, 64 percent lean and 35 percent fat. Page 169

22. *Fore Shank Cuts.*—Soup bones from the fore shank varied from 17 to 69 percent lean, and from 25 to 75 percent bone. The boneless shank stew contained 83 percent lean and 17 percent visible fat. Page 169

23. *Retail Trimmings.*—Trimming the loin steaks reduced their weight 12 percent, and the trimmings were about four-fifths fat and one-fifth bone. Round and chuck steaks were reduced but 5 percent in weight by trimming, only fat being taken from the former, as a rule, and principally bone from the latter. Other cuts that were materially affected by cutting off surplus fat and bone were the rump, shoulder pot roast, and neck. Pages 165-168

24. *Relative Economy.*—Of the various steaks, the porterhouse cuts were highest in net cost of edible meat, and chuck steaks lowest. Of the roasts, the first cut of the prime ribs was relatively dearest and the rump cheapest. The most expensive boiling and stewing cuts, in terms of edible meat, were the shoulder pot roast and clod, while the rib ends and brisket cost the most with respect to lean meat alone, and the shank stew and neck were most economical, either as source of lean or of total meat. Soup bones were exceedingly variable in relative economy, the middle cuts from the shanks being relatively cheapest, and the hock and end of the fore shank most expensive. Page 170

In general, the low-priced cuts were by far the most economical sources both of lean and of total edible meat. It is evident, therefore, that market prices of the various retail cuts of beef are determined chiefly by considerations other than their relative food values. Page 172

In the preparation of samples and in the analytical work of this investigation, valuable assistance was rendered by P. F. Trowbridge, Elizabeth C. Sprague, L. F. Shackell and J. M. Barnhart.

PHOTOGRAPHS OF THE RETAIL CUTS

The following figures, Nos. 13 to 69, are photographs of all the retail cuts of steer No. 3. As previously stated, this was the fattest of the three steers and was not only highly finished, but somewhat over-done. Consequently the illustrations do not represent ideal cuts of beef, but show a larger proportion of fat than usually is desirable. The photographs were taken before trimming. For the amount and nature of the trimmings from each cut see Tables 33 to 38, Appendix. The numbers of the retail cuts refer to those indicated in Fig. 12, page 164. The instances in which these numbers are not consecutive are due to slight differences in thickness of the cuts. Below is shown the order of the photographs.

	Fig. No.
Loin steaks	13 to 28
Rib roasts	29 to 32
Rump roast	33
Round steaks	34 to 42
Round pot roast and soup bones	43 to 45
Chuck rib roast	46
Chuck steaks	47 to 54
Chuck pot roasts and stews	55 to 60
Plate cuts: brisket, navel and rib ends	61 to 64
Flank steak and stew	65 to 66
Fore shank stew and soup bones	67 to 69

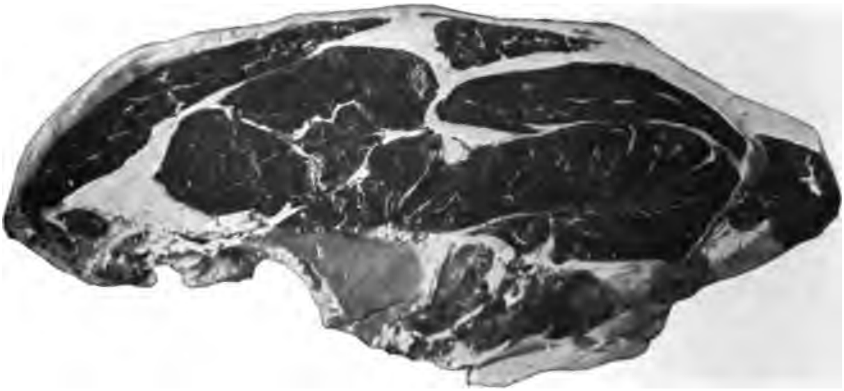

Fig. 13. Butt-end sirloin steak. Loin Cut No. 1.

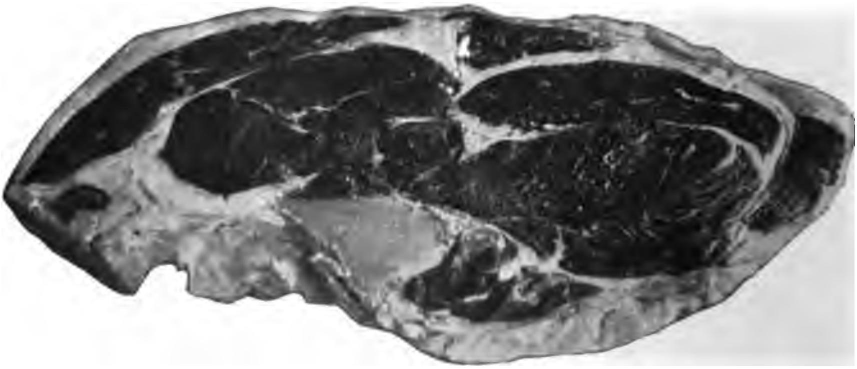

Fig. 14. Wedge-bone sirloin steak. Loin cut No. 2.

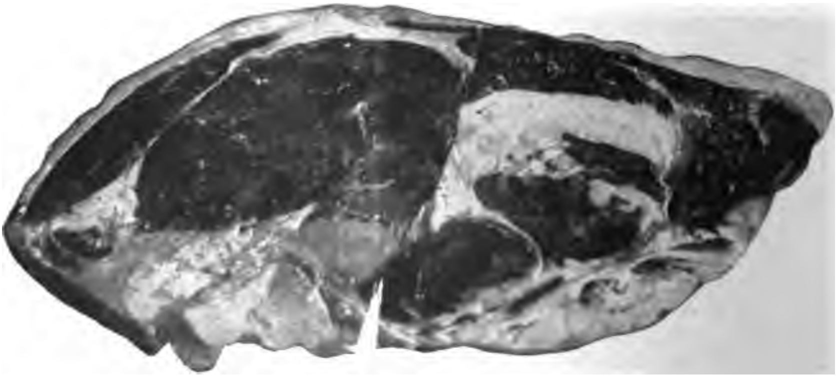

Fig. 15. Round-bon sirloin steak. Loin cut No. 3.

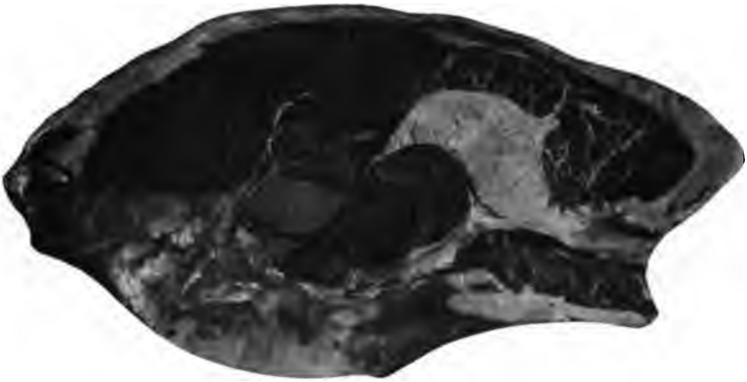

Fig. 16. Round-bone sirloin steak. Loin cut No. 4.

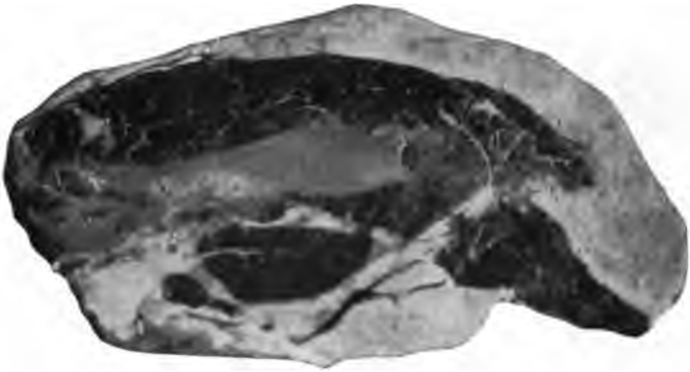

Fig. 17. Double-bone sirloin steak. Loin cut No. 5.

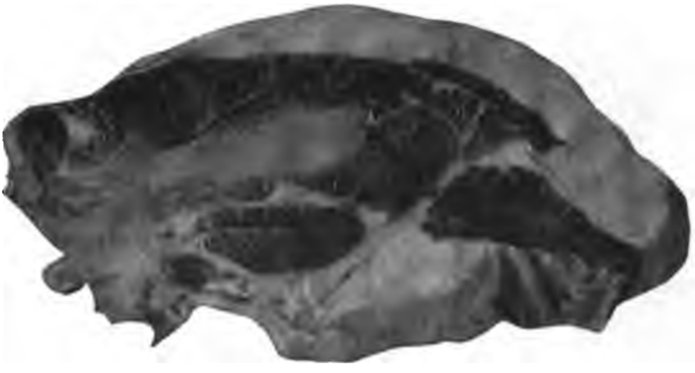

Fig. 18. Hip-bone sirloin steak. Loin cut No. 7.

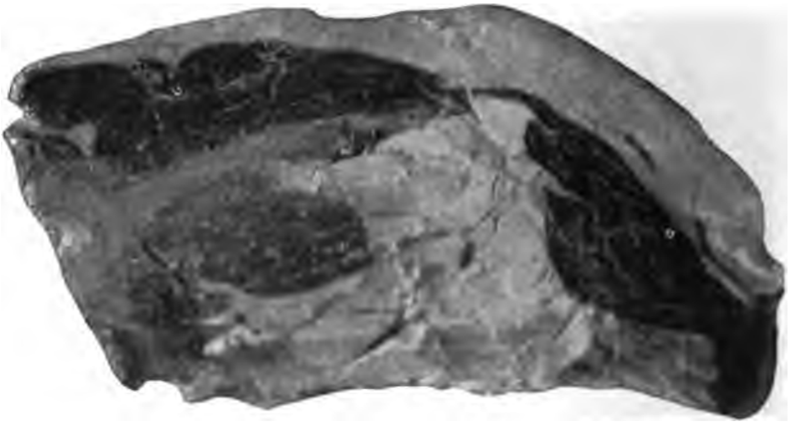

Fig. 19. Hip-bone porterhouse steak. Loin cut No. 8.

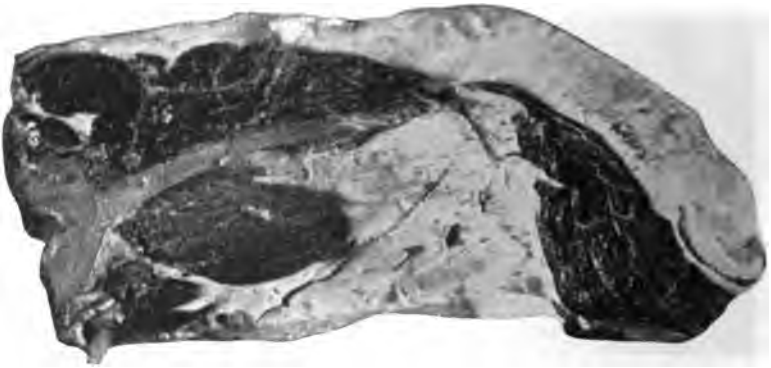

Fig. 20. Regular porterhouse steak. Loin cut No. 9.

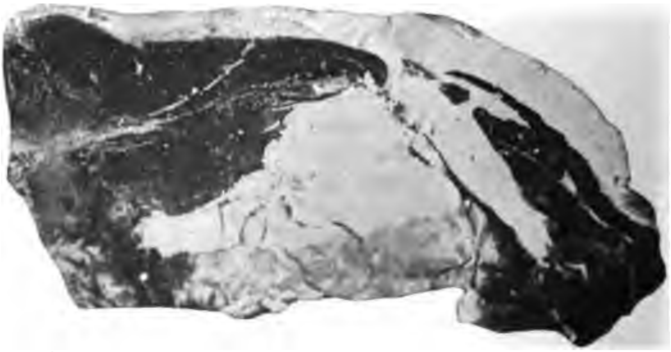

Fig. 21. Regular porterhouse steak. Loin cut No. 10.

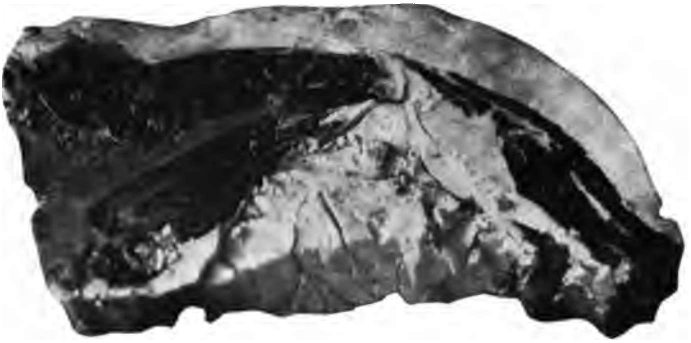

Fig. 22. Regular porterhouse steak. Loin cut No. 12.

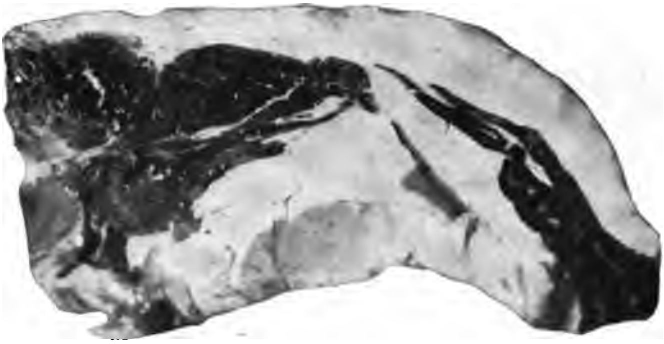

Fig. 23. Regular porterhouse steak. Loin cut No. 13.

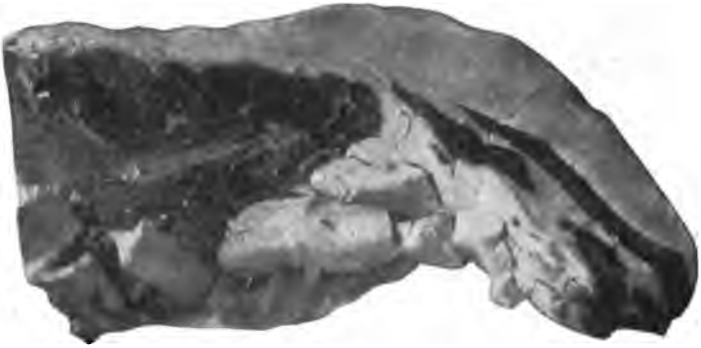

Fig. 24. Regular porterhouse steak. Loin cut No. 14.

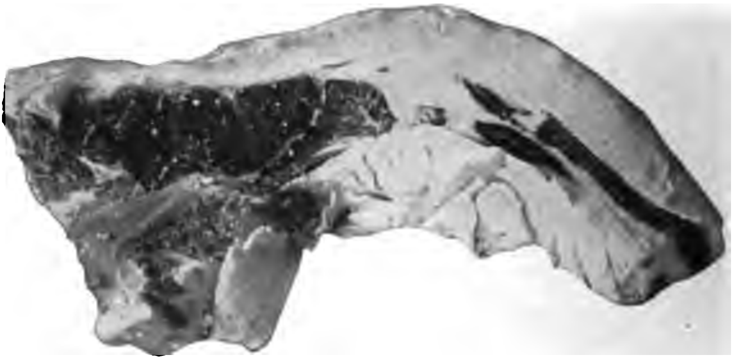

Fig. 25. Regular porterhouse steak. Loin cut No. 15.

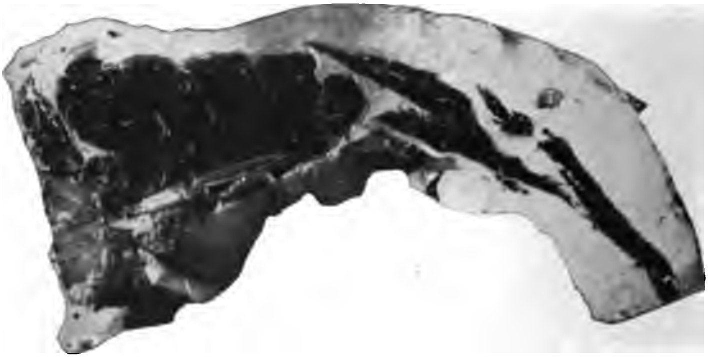

Fig. 26. Club steak. Loin cut No. 16.

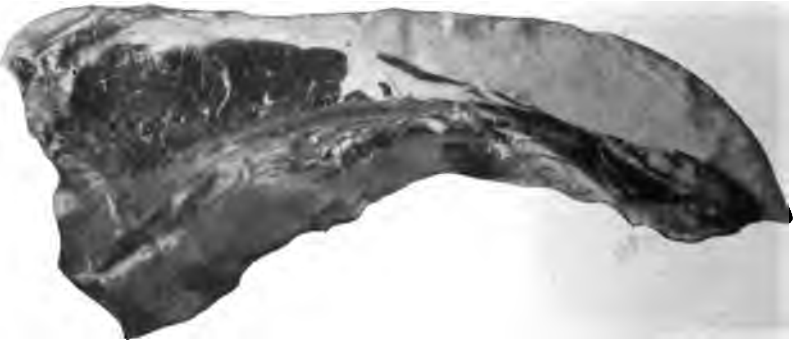

Fig. 27. Club steak. Loin cut No. 17.

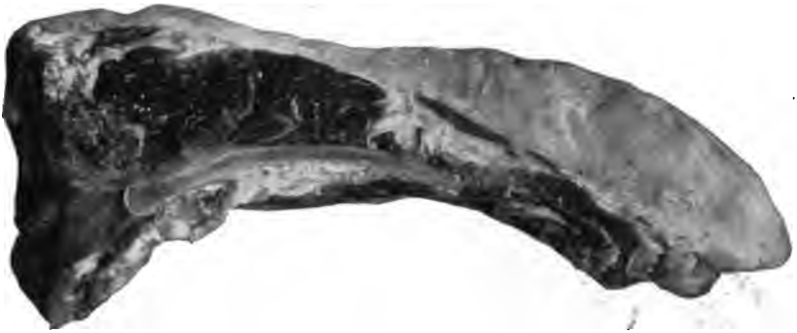

Fig. 28. Club steak. Loin cut No. 18.

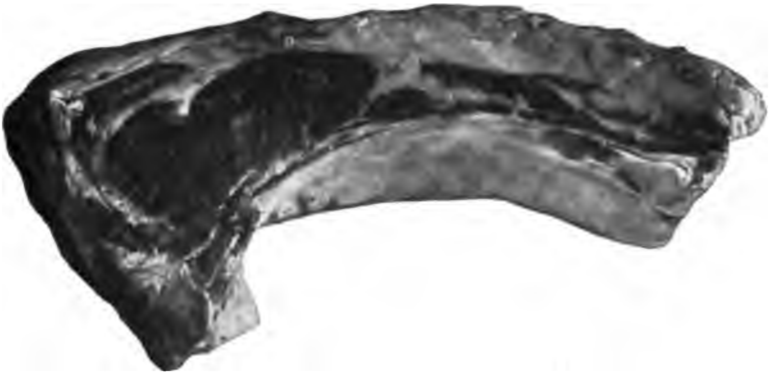

Fig. 29. 11th and 12th rib roast. Rib cut No. 1.

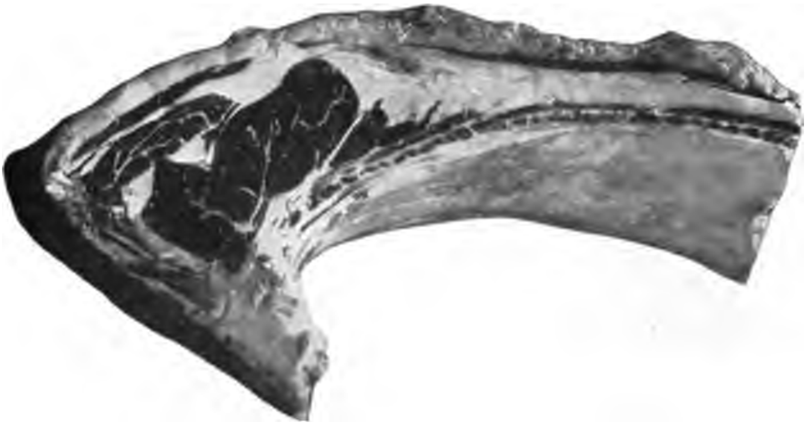

Fig. 30. 9th and 10th rib roast. Rib cut No. 2.

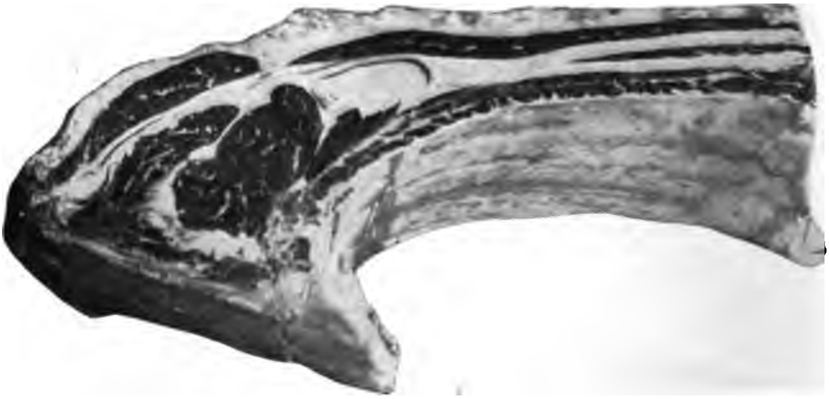

Fig. 31. 7th and 8th rib roast. Rib cut No. 3.

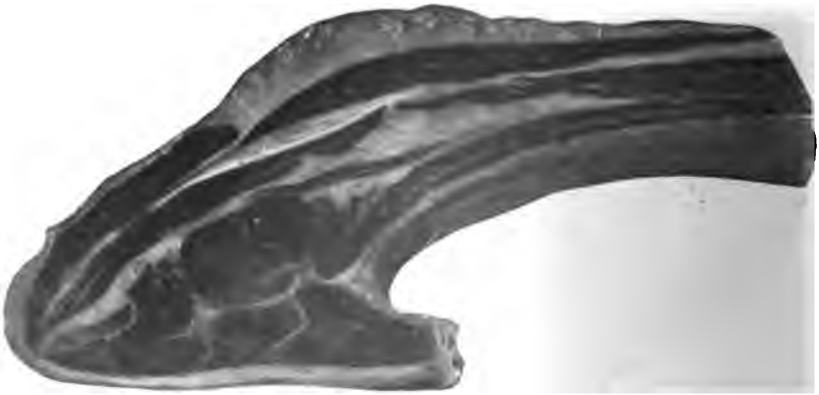

Fig. 32. 6th rib roast. Rib cut No. 4.

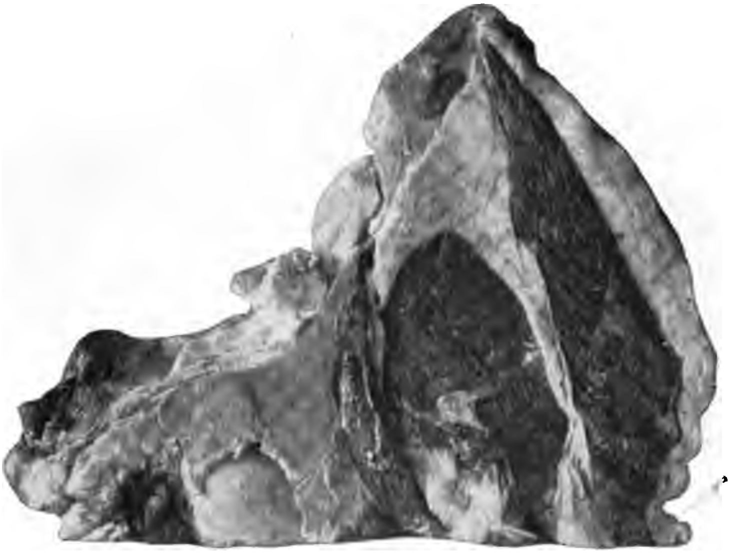

Fig. 33. Rump roast. Round cut No. 1.

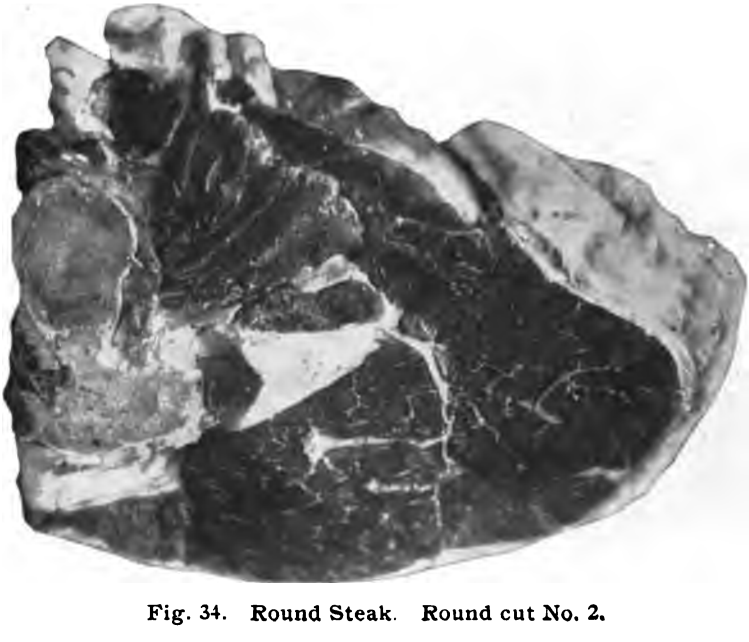

Fig. 34. Round Steak. Round cut No. 2.

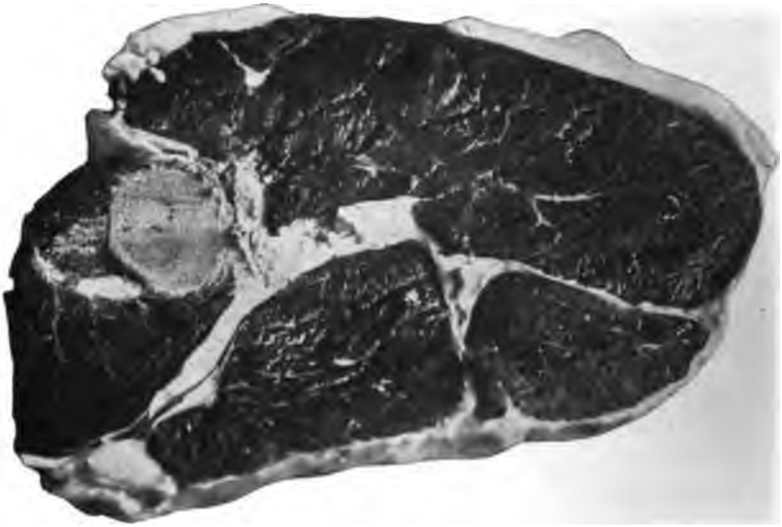

Fig. 35. Round steak. Round cut No. 3.

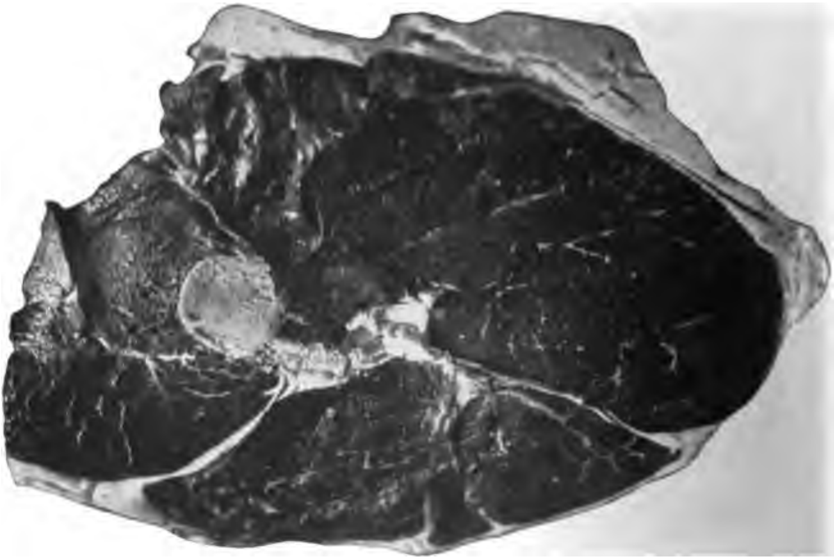

Fig. 36. Round steak. Round cut No. 4.

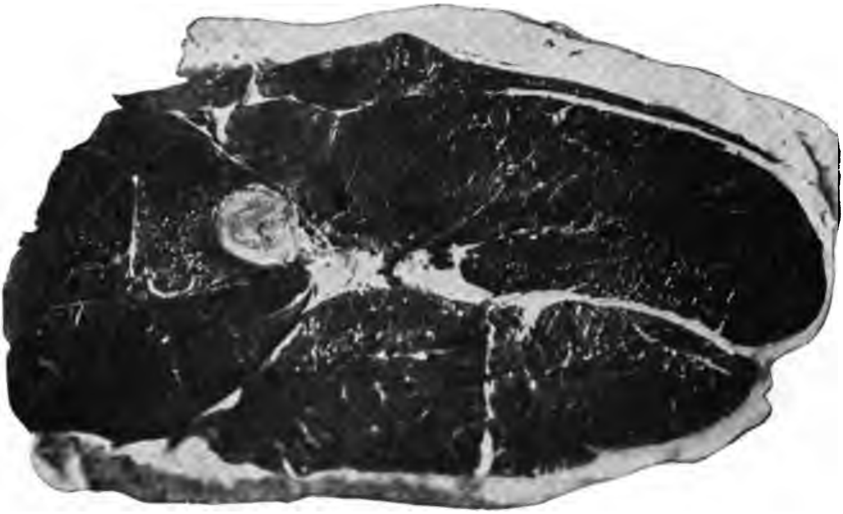

Fig. 37. Round steak. Round cut No. 5.

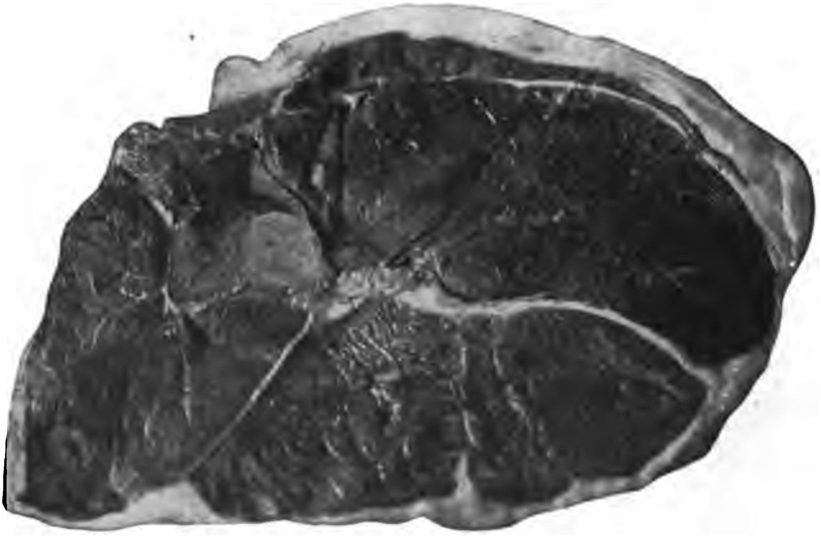

Fig. 38. Round steak. Round cut No. 6.

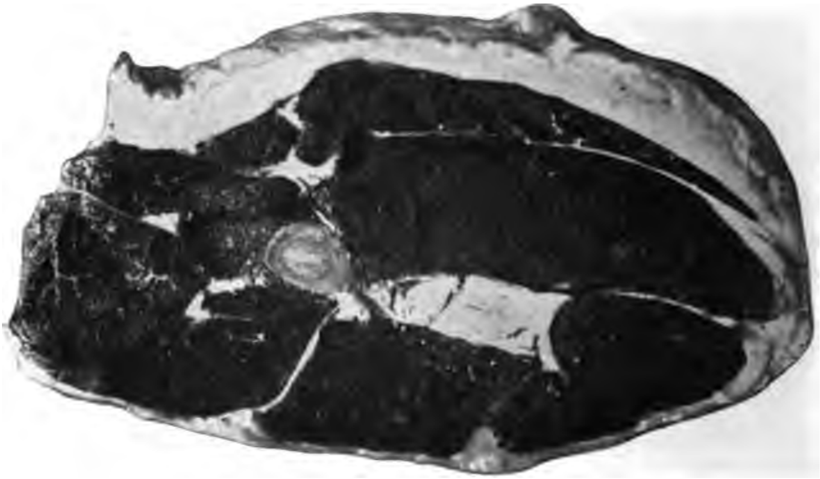

Fig. 39. Round Steak. Round cut No. 7.

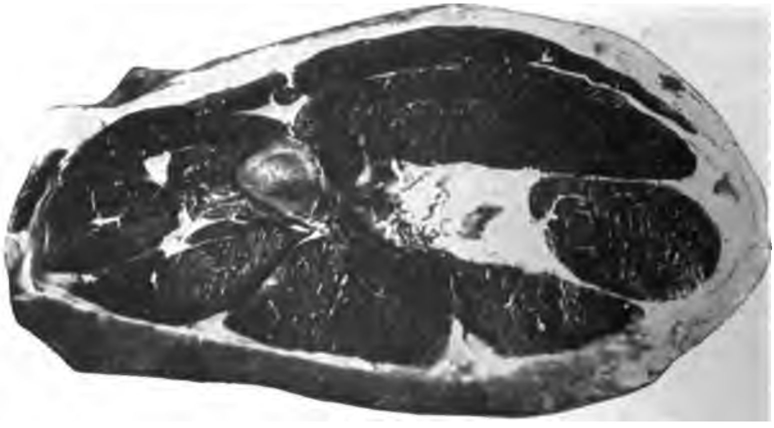

Fig. 40. Round steak. Round cut No. 8.

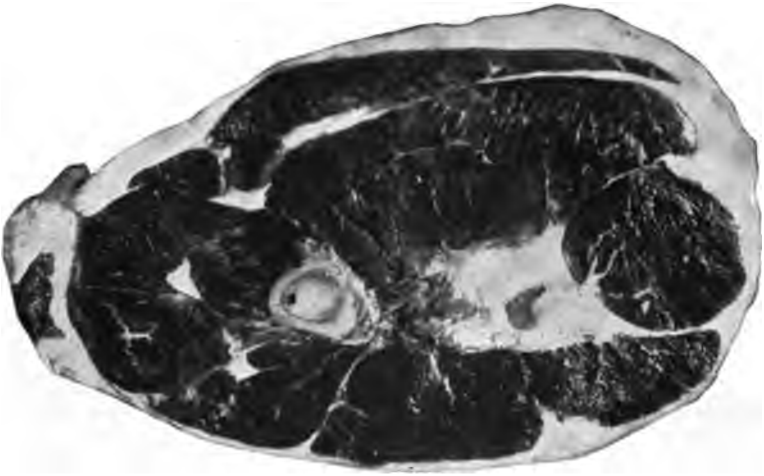

Fig. 41. Round steak. Round cut No. 12.

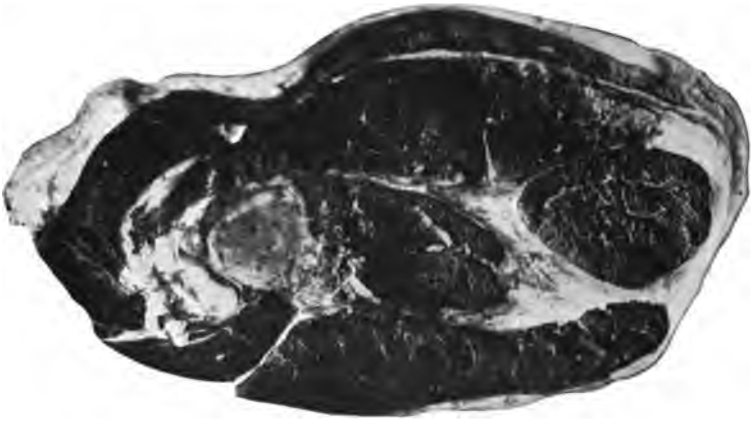

Fig. 42. Round steak. Round cut No. 14.

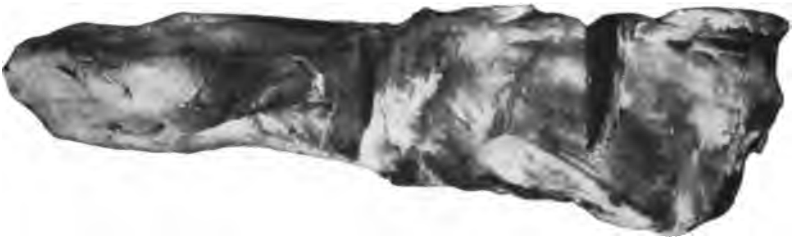

Fig. 43. Hind shank soup bone. Round cuts Nos. 17, 18, 19.

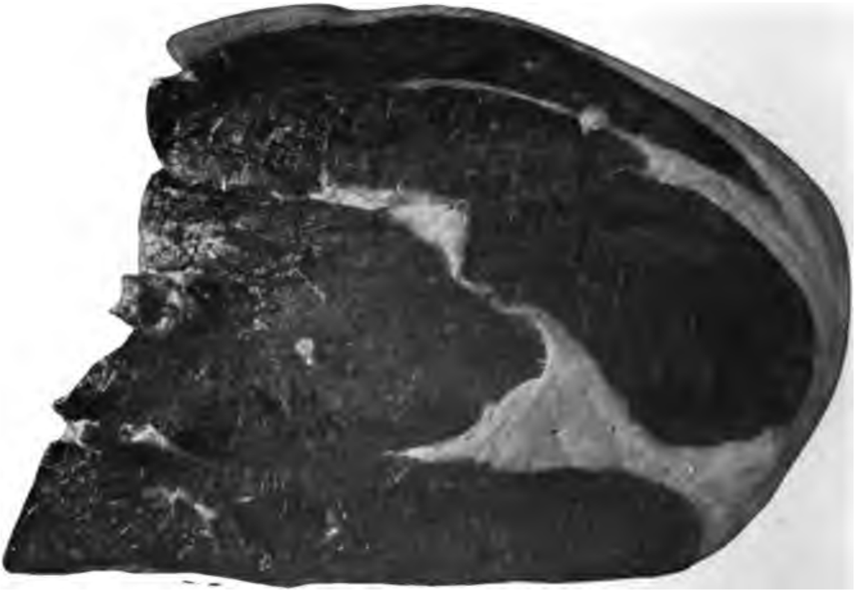

Fig. 44. Round pot roast. Round cut No. 16.

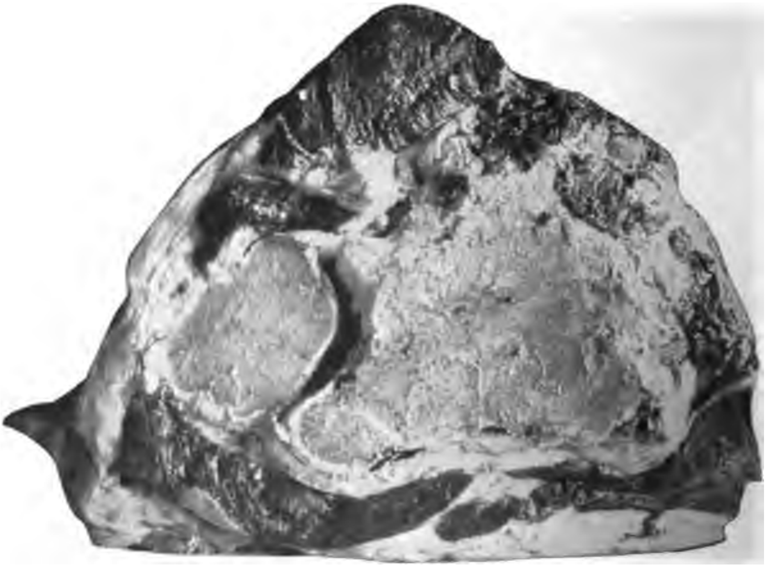

Fig. 45. Knuckle soup bone. Round cut No. 15.

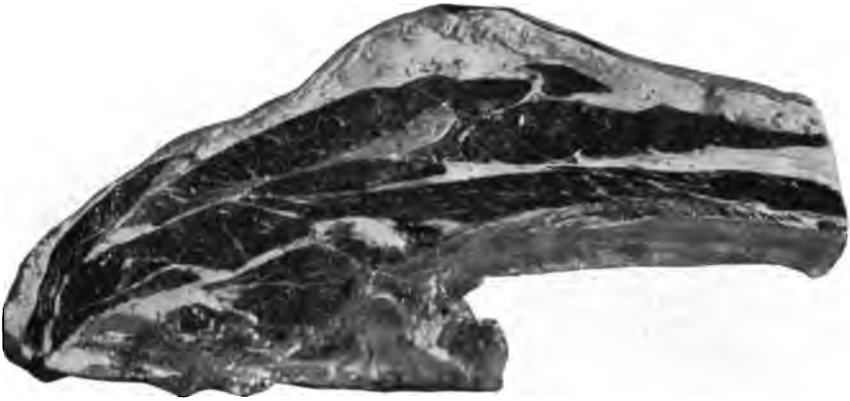

Fig. 46. Chuck rib roast. Chuck cut No. 1.

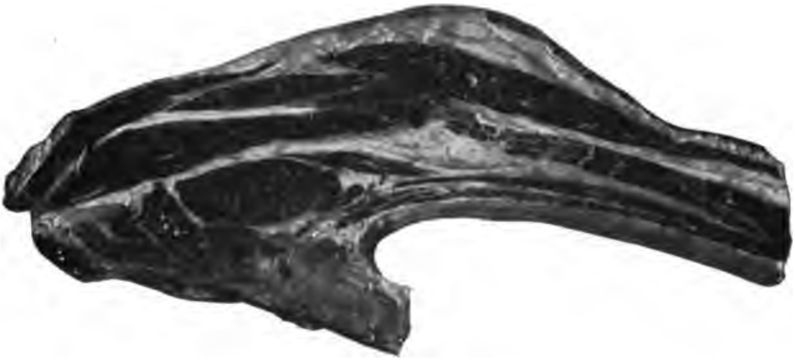

Fig. 47. Chuck steak. Chuck cut No. 2.

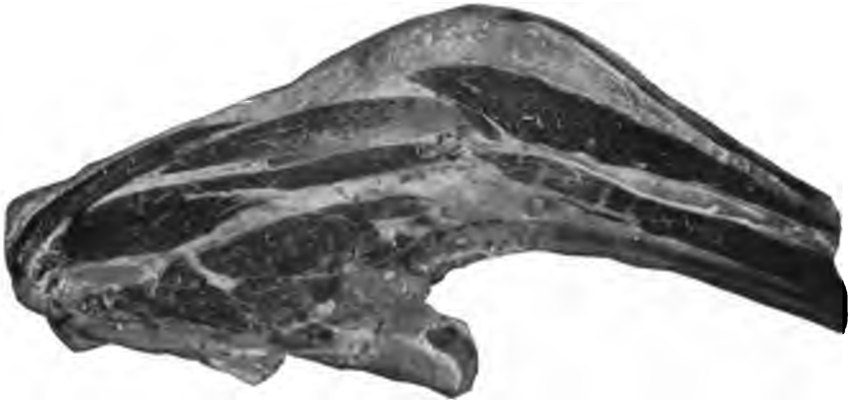

Fig. 48 Chuck steak. Chuck cut No. 3.

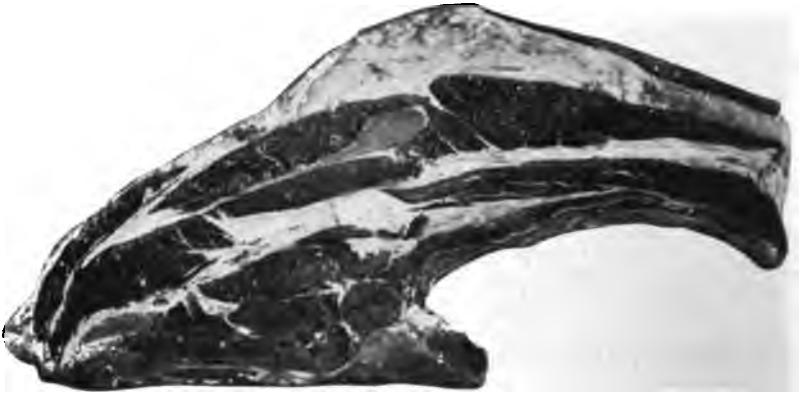

Fig. 49. Chuck steak. Chuck cut No. 4.

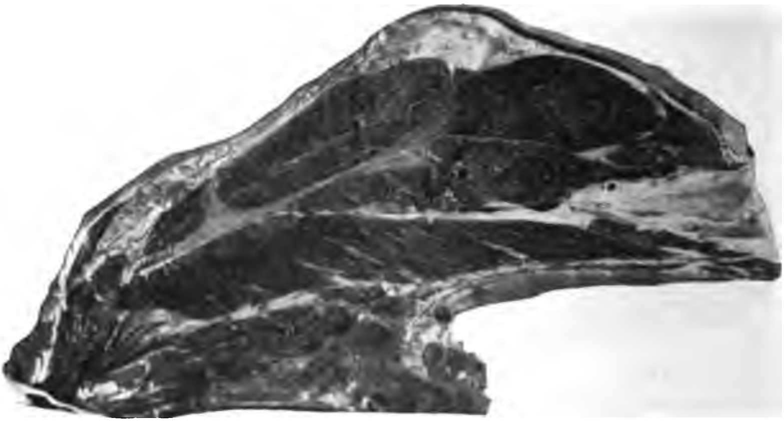

Fig. 50. Chuck steak. Chuck cut No. 5.

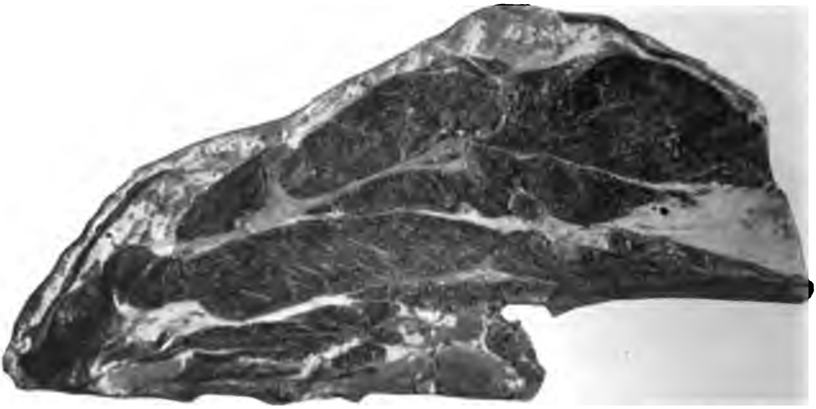

Fig. 51. Chuck steak. Chuck cut No. 6.

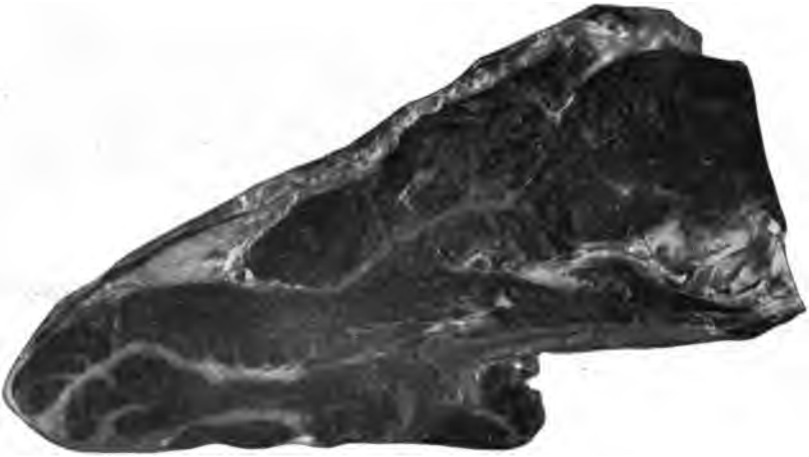

Fig. 52. Chuck steak. Chuck cut No. 7.

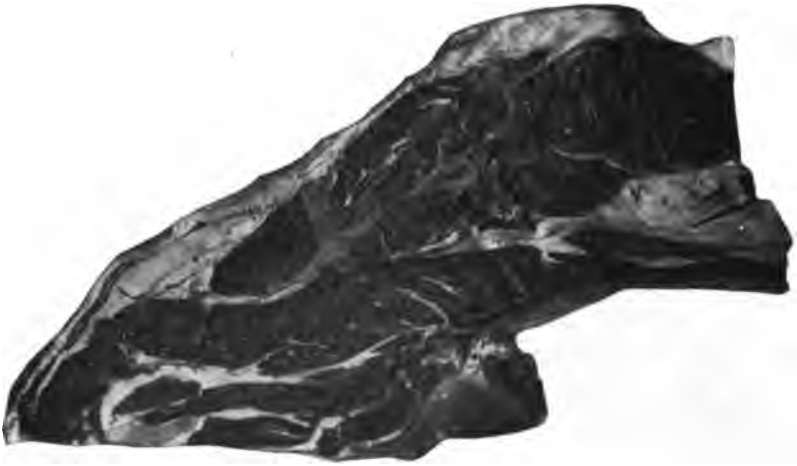

Fig. 53. Chuck steak. Chuck cut No. 8.

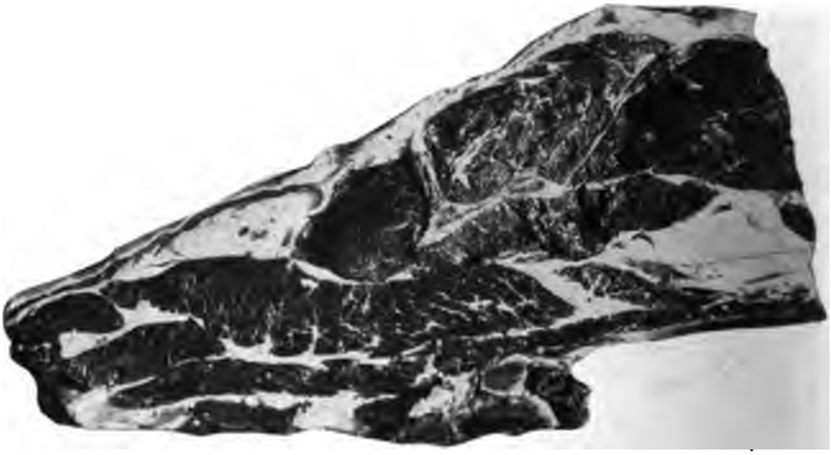

Fig. 54. Chuck steak. Chuck cut No. 9.

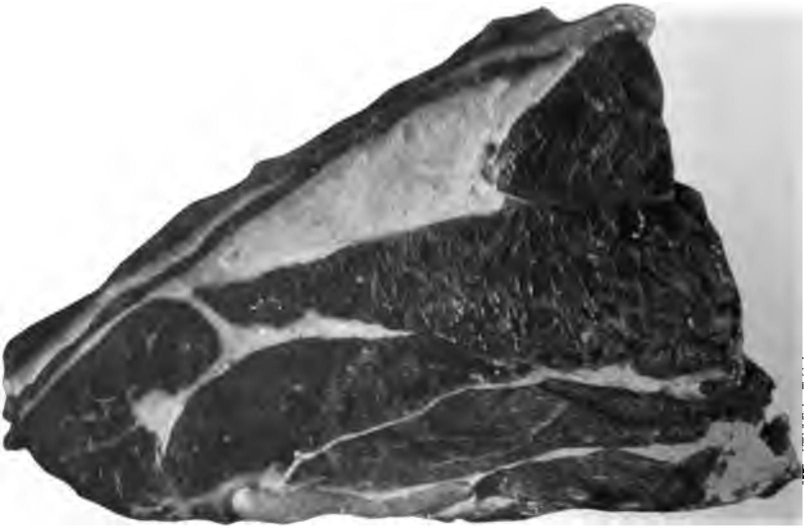

Fig. 55. Shoulder pot roast. Chuck cut No. 10.

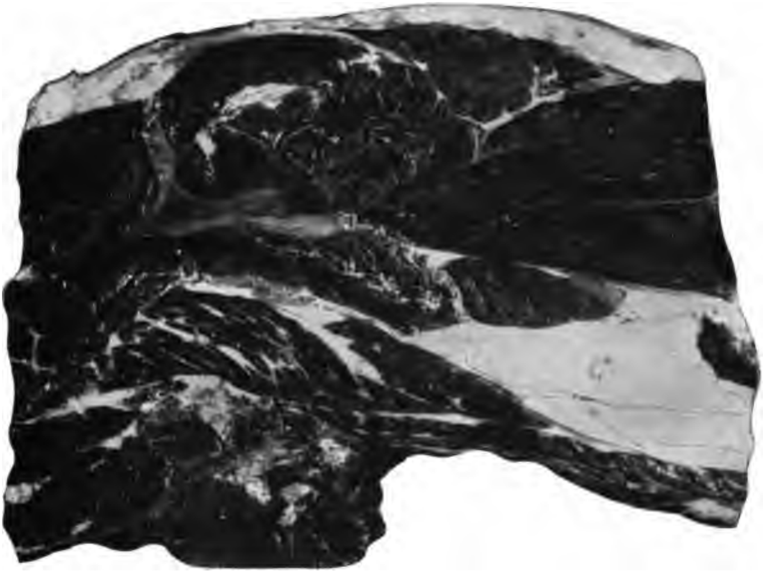

Fig. 56. Shoulder pot roast. Chuck cut No. 11.

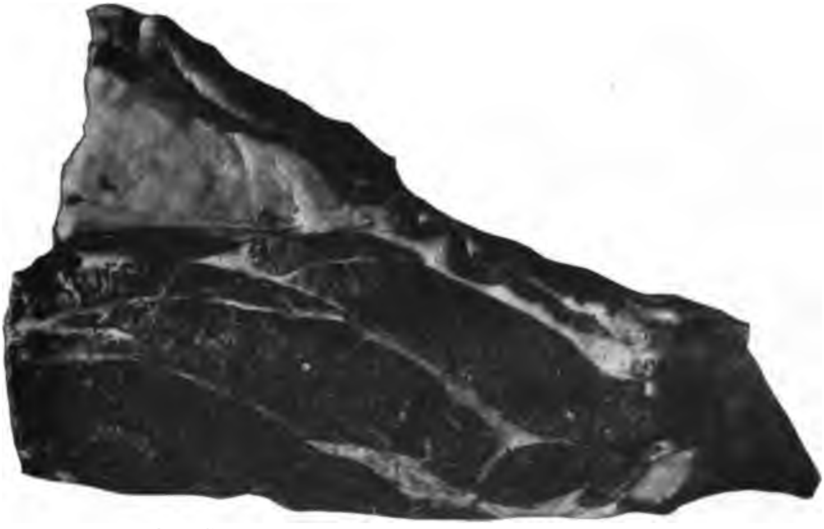

Fig. 57. Shoulder pot roast. Chuck cut No. 12.

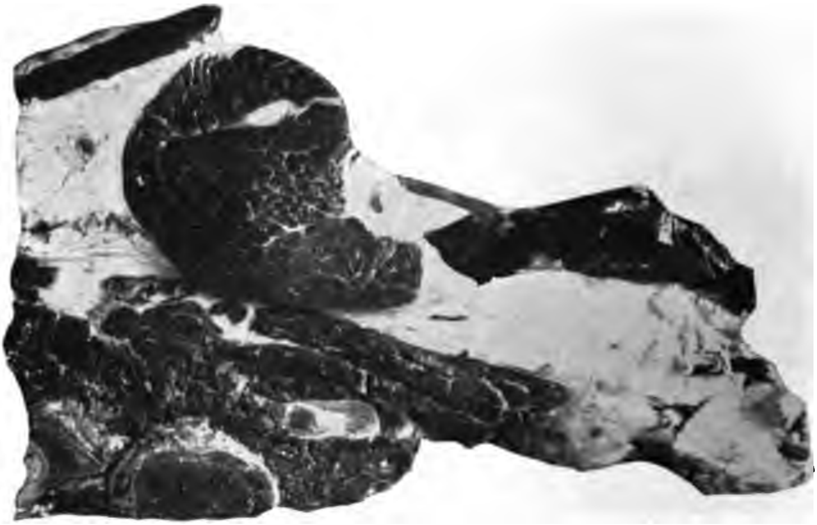

Fig. 58. Chuck stew. Chuck cut No 13.

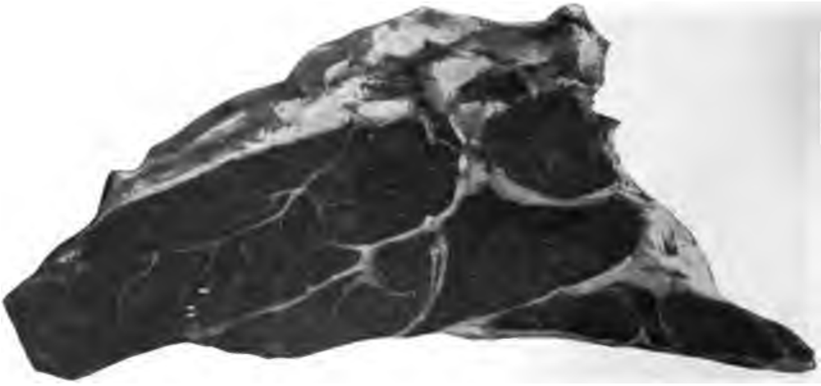

Fig. 59. Shoulder clod. Chuck cut No. 14.

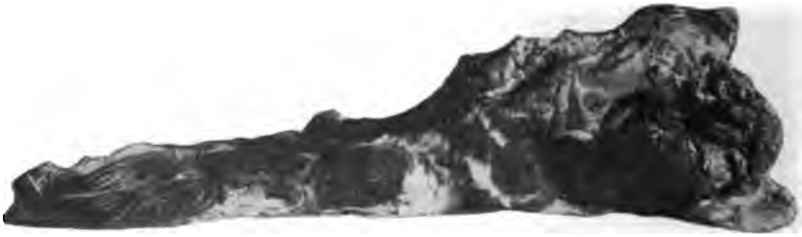

Fig. 60. Neck Chuck cut No. 15.

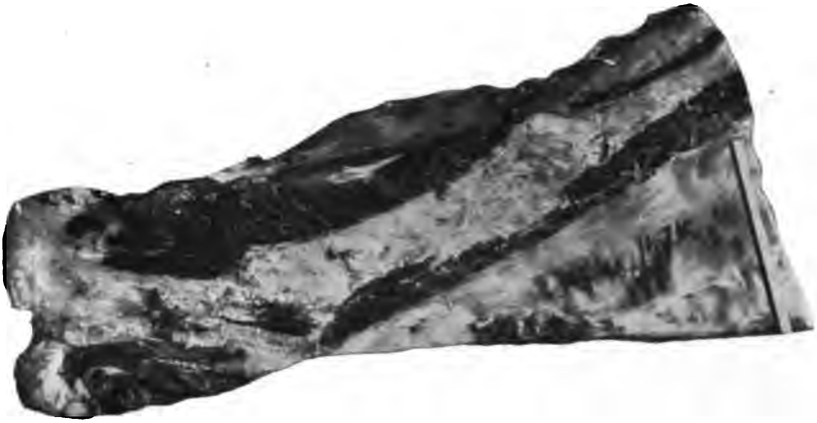

Fig. 61. Brisket. Plate cut No. 1.

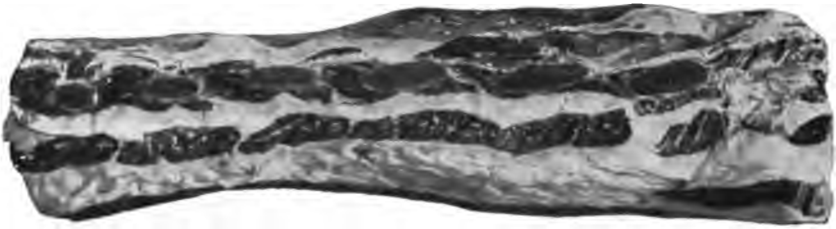

Fig. 62. Navel. Plate cut No. 2.

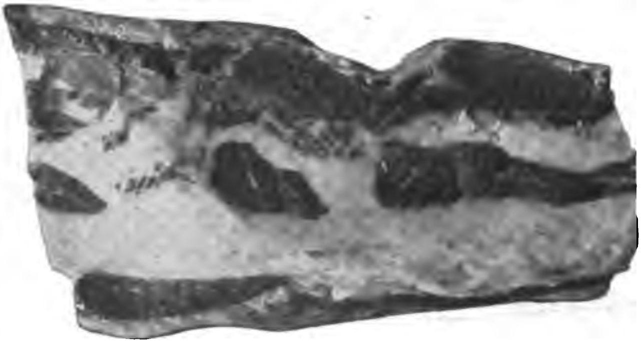

Fig. 63. Rib ends. Plate cut No. 3.

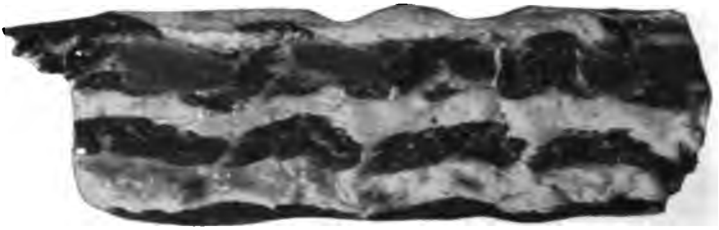

Fig. 64. Rib ends. Plate cut No. 4.

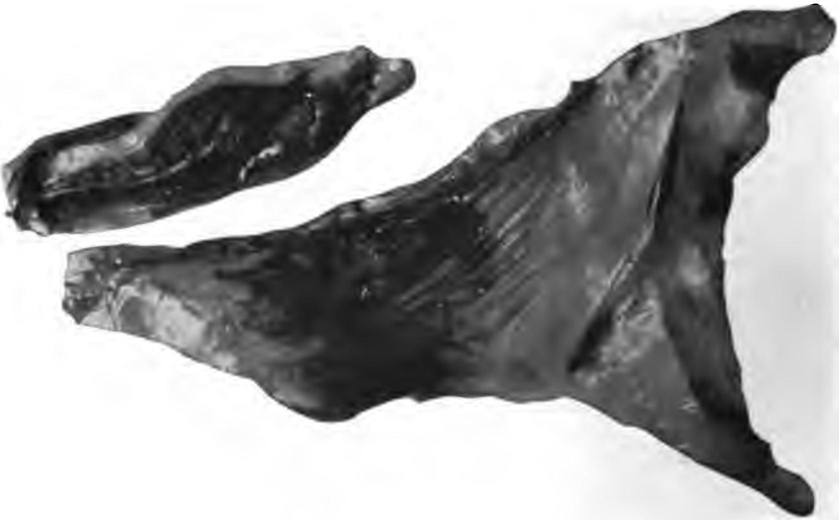

Fig. 65. Flank stew. Flank cut No. 1.

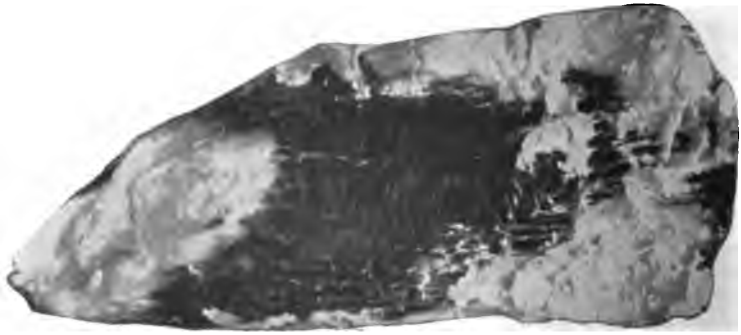

Fig. 66. Flank steak. Flank cut No. 2.

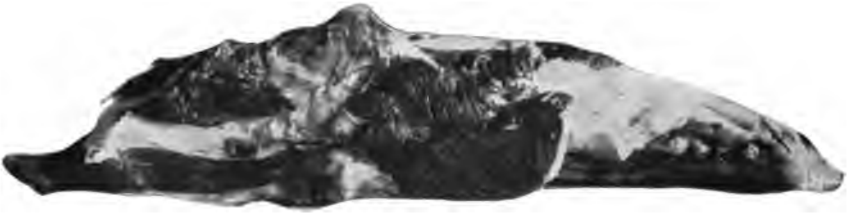

Fig. 67. Shank Stew. Fore shank cut No. 1.

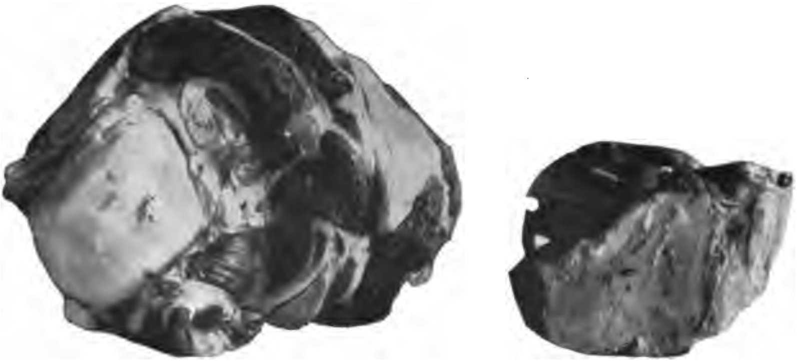

Fig. 68. Knuckle soup bones. Fore shank cuts Nos. 2, 3.

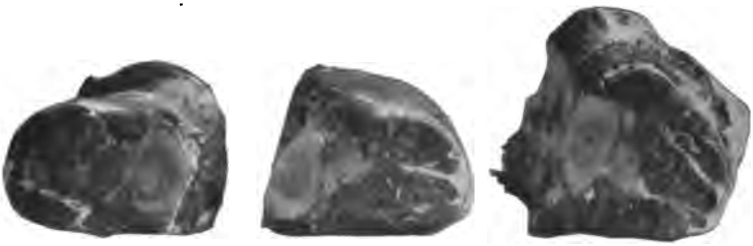

Fig. 69. Fore shank soup bones. Fore shank cuts Nos. 4, 5, 6.

APPENDIX

The results presented in the text of this bulletin are, in the main, averages based on data obtained from the carcasses of three steers, one side of beef being used in each instance. For the convenience of any who may wish to study the individual results, the cutting tests and chemical analyses are tabulated in full on the following pages.

Wholesale cuts of three sides of beef:
  Weights and percentages of lean, visible fat, and bone. Tables 1 and 2........................Pages 201-202
Chemical analysis of boneless meat from three sides of beef:
  Percentage composition of wholesale cuts, Tables 3, 4 and 5 ....Pages 203-205
  Percentage composition and weight of nutrients in fore quarter, hind quarter, and entire side. Tables 6 and 7 ....Pages 206-207
  Ratio, non-protein to protein nitrogen in the wholesale cuts. Table 8.............................Page 208
  Percentage composition of visible fat. Table 9.....Page 208
Retail cuts from three sides of beef:
  Weights and percentages of lean, visible fat, and bone in entire cuts. Tables 10 to 23............Pages 209-218
  Weights and percentages of lean, visible fat, and bone in trimmed loin, round, and chuck cuts. Tables 24 to 32 ....Pages 219-227
  Weights and percentages of lean, visible fat, and bone in trimmings from loin, round and chuck cuts. Tables 33 to 38............................Pages 228-233

TABLE 1.—LEAN, VISIBLE FAT, AND BONE IN THE WHOLESALE CUTS, EXPRESSED IN POUNDS

Wholesale cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
Loin	26.81	12.19	3.58	42.58	38.70	17.80	5.61	63.45	36.38	27.17	6.64	70.46
Rib	15.24	6.94	4.35	26.53	20.68	10.26	4.37	35.78	20.49	14.34	5.69	40.52
Round	39.37	10.30	10.48	60.15	51.48	10.59	13.66	77.12	56.75	21.41	13.59	92.11
Round, R. and S. off	30.27	5.81	3.51	39.59	41.54	6.58	5.47	54.58	45.26	13.82	5.28	64.36
Hind shank	3.12	.54	4.49	8.15	3.87	.64	5.69	10.42	4.41	2.68	5.53	12.63
Rump	6.00	3.95	2.49	12.44	6.01	3.44	2.50	12.11	7.08	4.90	2.77	14.75
Chuck	43.96	10.15	7.75	61.86	54.97	12.80	7.93	77.07	60.46	20.93	10.03	91.55
Chuck, knuckle out	35.27	7.66	6.46	49.39	46.91	11.05	7.25	66.38	53.87	18.92	8.80	81.89
Clod	3.45	.55	.22	4.22	4.76	.58	.25	5.64	4.74	1.29	.28	6.31
Neck	5.23	1.93	1.09	8.25	3.33	1.15	.44	5.06	1.84	.72	.97	3.53
Plate	20.95	15.36	3.82	40.13	29.09	18.28	4.29	51.95	31.63	35.34	5.53	72.50
Flank	5.80	8.71	.02	14.53	7.58	11.53	.06	19.30	6.06	14.25	.06	20.37
Fore shank	7.20	1.15	5.58	13.93	7.86	1.27	7.09	16.50	9.55	4.16	8.25	21.96
Kidney suet	.95	9.70	0	10.65	.93	16.10	0	17.03	1.00	14.06	0	15.06
Entire side	160.28	74.50	35.58	270.36	211.24	98.65	43.41	357.72	222.33	151.66	49.79	424.56

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[1] Includes loss and error in weighing.

TABLE 2.—LEAN, VISIBLE FAT, AND BONE IN THE WHOLESALE CUTS, EXPRESSED IN PERCENT

Wholesale cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
Loin	62.96	28.63	8.41	100.00	60.99	28.05	8.84	97.88	51.63	38.56	9.41	99.60
Rib	57.44	26.16	16.40	100.00	57.80	28.67	12.21	98.68	50.57	35.39	14.04	100.00
Round	65.46	17.12	17.42	100.00	66.75	13.73	17.71	98.19	61.61	23.24	14.75	99.60
Round, R. and S. off	76.46	14.67	8.87	100.00	76.11	12.06	10.02	98.19	70.32	21.47	8.20	99.99
Hind shank	38.46	6.51	55.03	100.00	37.14	6.14	54.61	97.89	34.92	21.22	43.78	100.00
Rump	48.23	31.75	20.02	100.00	49.63	28.38	20.65	98.66	47.98	33.26	18.76	100.00
Chuck	71.06	16.41	12.53	100.00	71.32	16.61	10.29	98.22	66.04	22.86	10.96	99.86
Chuck, knuckle out	71.41	15.51	13.08	100.00	70.67	16.65	10.92	98.24	65.78	23.10	10.75	99.63
Clod	81.75	13.03	5.21	100.00	84.40	10.28	4.43	99.11	75.00	20.55	4.45	100.00
Neck	63.39	23.28	13.33	100.00	65.81	22.73	8.69	97.23	52.21	20.36	27.43	100.00
Plate	52.21	38.27	9.52	100.00	55.99	35.11	8.26	99.37	43.63	48.74	7.63	100.00
Flank	39.92	59.94	.14	100.00	39.27	59.74	.31	99.32	29.71	69.85	.29	99.85
Fore shank	51.69	8.25	40.06	100.00	47.64	7.70	42.97	98.30	43.49	18.94	37.57	100.00
Kidney suet	8.92	91.08	0	100.00	5.46	94.54	0	100.00	6.64	93.36	0	100.00
Entire side	59.28	27.56	13.16	100.00	59.05	27.58	12.14	98.77	52.37	35.72	11.73	99.82

TABLE 3.—CHEMICAL COMPOSITION OF THE BONELESS MEAT OF THE WHOLESALE CUTS FROM STEER NO. 1, EXPRESSED IN PERCENT

Constituents	Hind shank	Round	Rump	Loin	Rib	Flank	Plate	Chuck	Clod	Neck	Fore shank
Water	63.62	61.75	46.97	50.02	49.08	33.03	40.69	56.54	65.07	55.27	60.79
Dry substance											
Soluble	4.22	4.84	3.58	3.83	3.28	1.82	2.45	3.82	4.68	3.60	3.81
Insoluble	32.89	33.18	49.81	46.70	47.90	65.59	56.94	40.54	30.77	41.36	35.64
Total	37.11	38.02	53.39	50.53	51.18	67.41	59.39	44.36	35.45	44.96	39.45
Soluble protein											
Coagulable protein	1.60	2.21	1.28	1.42	1.22	.70	84	1.38	2.01	1.41	1.39
Non-coagulable protein	.24	.12	.11	.14	.12	.08	.09	.29	.22	.28	.09
Total	1.84	2.33	1.39	1.56	1.34	.78	.93	1.67	2.23	1.69	1.48
Insoluble protein	15.27	14.31	11.51	11.91	11.80	9.55	10.32	13.59	15.11	13.25	15.19
Total protein	17.11	16.64	12.90	13.47	13.14	10.33	11.25	15.26	17.34	14.94	16.67
Organic extractives											
Nitrogenous	.84	.89	.66	.79	.68	.34	.51	.76	.78	.69	.79
Non-nitrogenous	.81	.89	1.00	.93	.73	.39	.58	.74	.98	.61	.87
Total	1.65	1.78	1.66	1.72	1.41	.73	1.09	1.50	1.76	1.30	1.66
Fat	17.47	18.73	38.23	34.76	36.02	55.97	46.56	26.82	15.46	28.00	20.30
Ash											
Soluble	.73	.73	.54	.55	.53	.30	.43	.65	.70	.60	.67
Insoluble	.14	.14	.06	.03	.10	.07	.06	.13	.19	.12	.15
Total	.87	.87	.60	.58	.63	.37	.49	.78	.89	.72	.82
Nitrogen											
Soluble coagulable protein	.255	.353	.205	.226	.196	.112	.124	.230	.322	.183	.223
Soluble non-coagulable protein	.038	.020	.016	.024	.018	.014	.025	.036	.033	.087	.014
Total protein	.293	.373	.221	.250	.214	.126	.149	.266	.355	.270	.237
Soluble non-protein	.269	.286	.212	.253	.218	.110	.163	.246	.252	.224	.251
Total soluble nitrogen	.562	.659	.433	.503	.432	.236	.312	.512	.607	.494	.488
Insoluble protein	2.444	2.289	1.843	1.906	1.888	1.527	1.650	2.176	2.419	2.119	2.431
Total nitrogen	3.006	2.948	2.276	2.409	2.320	1.763	1.962	2.688	3.026	2.613	2.919
Phosphorus											
Soluble inorganic	.095	.082	.055	.066	.067	.044	.045	.088	.100	.086	.093
Soluble organic	.035	.042	.029	.031	.029	.011	.030	.025	.044	.021	.024
Total soluble	.130	.124	.084	.097	.096	.055	.075	.113	.144	.107	.117
Insoluble	.050	.069	.048	.049	.037	.027	.031	.056	.046	.041	.059
Total phosphorus	.180	.193	.132	.146	.133	.082	.106	.169	.190	.148	.176

TABLE 4.—CHEMICAL COMPOSITION OF THE BONELESS MEAT OF THE WHOLESALE CUTS FROM STEER NO. 2, EXPRESSED IN PERCENT

Constituents	Hind shank	Round	Rump	Loin	Rib	Flank	Plate	Chuck	Clod	Neck	Fore shank
Water	62.65	61.94	46.65	49.09	45.37	33.32	42.45	57.78	63.59	54.35	62.95
Dry substance											
Soluble	4.33	5.24	3.58	3.92	3.30	2.03	2.80	4.36	4.96	4.00	4.15
Insoluble	33.46	32.87	50.10	47.28	51.60	64.80	54.96	38.29	31.71	42.52	33.31
Total	37.79	38.11	53.68	51.20	54.90	66.83	57.76	42.65	36.67	46.52	37.46
Soluble protein											
Coagulable protein	1.56	2.03	1.31	1.46	1.19	.68	.96	1.67	1.74	1.50	1.49
Non-coagulable protein	.11	.16	.10	.13	.11	.09	.09	.15	.13	.11	.10
Total	1.67	2.19	1.41	1.59	1.30	.77	1.05	1.82	1.87	1.61	1.59
Insoluble protein	14.85	15.18	11.67	12.14	11.58	8.97	10.69	13.98	15.27	13.95	16.32
Total protein	16.52	17.37	13.08	13.73	12.88	9.74	11.74	15.80	17.14	15.56	17.91
Organic extractives											
Nitrogenous	.85	1.04	.69	.76	.64	.43	.55	.80	.99	.75	.81
Non-nitrogenous	1.12	1.22	.93	.98	.87	.51	.76	1.02	1.32	1.01	1.04
Total	1.97	2.26	1.62	1.74	1.51	.94	1.31	1.82	2.31	1.76	1.85
Fat	18.43	17.54	38.27	34.99	39.82	55.66	44.08	24.15	16.34	28.42	16.78
Ash											
Soluble	.69	.80	.55	.59	.49	.32	.44	.72	.78	.63	.72
Insoluble	.18	.14	.16	.15	.20	.17	.19	.16	.10	.15	.21
Total	.87	.94	.71	.74	.69	.49	.63	.88	.88	.78	.93
Nitrogen											
Soluble coagulable protein	.251	.325	.209	.233	.190	.108	.153	.267	.278	.242	.249
Soluble non-coagulable protein	.017	.033	.016	.021	.018	.015	.015	.024	.019	.017	.007
Total soluble protein	.268	.352	.225	.254	.208	.123	.168	.291	.297	.259	.256
Soluble non-protein	.272	.331	.217	.243	.205	.136	.174	.259	.318	.239	.261
Total soluble nitrogen	.540	.683	.442	.497	.413	.259	.342	.550	.615	.498	.517
Insoluble protein	2.376	2.428	1.867	1.943	1.852	1.434	1.710	2.235	2.446	2.231	2.611
Total nitrogen	2.916	3.111	2.309	2.440	2.265	1.693	2.052	2.785	3.061	2.729	3.128
Phosphorus[1]											

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[1] Phosphorus was not determined.

TABLE 5.—CHEMICAL COMPOSITION OF THE BONELESS MEAT OF THE WHOLESALE CUTS FROM STEER NO. 3, EXPRESSED IN PERCENT

Constituents	Hind shank	Round	Rump	Loin	Rib	Flank	Plate	Chuck	Clod	Neck	Fore shank
Water	56.79	58.88	45.13	43.16	41.01	30.44	35.13	52.08	60.47	59.33	59.11
Dry substance											
Soluble	3.15	4.60	2.83	2.69	2.59	1.34	1.62	3.28	3.79	3.79	3.43
Insoluble	40.47	36.54	51.21	54.21	56.04	67.73	63.49	44.37	36.47	36.70	38.23
Total	43.62	41.14	54.04	56.90	58.63	69.07	65.11	47.65	40.26	40.49	41.66
Soluble protein											
Coagulable protein	1.18	1.59	.91	.90	.90	.37	.48	.86	1.25	1.57	1.11
Non-coagulable protein	.08	.13	.07	.06	.07	.06	.04	.07	.07	.07	.07
Total	1.26	1.72	.98	.96	.97	.43	.52	.93	1.32	1.64	1.18
Insoluble protein	13.88	13.78	10.73	10.71	9.97	7.81	8.26	12.63	14.27	14.63	15.18
Total protein	15.14	15.50	11.71	11.67	10.94	8.24	8.78	13.56	15.59	16.27	16.36
Organic extractives											
Nitrogenous	.56	.90	.55	.53	.49	.26	.31	.79	.75	.65	.63
Non-nitrogenous	.83	1.23	.80	.73	.66	.36	.53	.94	1.07	.90	1.06
Total	1.39	2.13	1.35	1.26	1.15	.62	.84	1.73	1.82	1.55	1.69
Fat	26.40	22.69	40.36	43.38	46.01	59.85	55.08	31.66	22.07	21.94	22.87
Ash											
Soluble	.50	.76	.50	.47	.47	.29	.26	.62	.65	.60	.56
Insoluble	.19	.06	.12	.12	.06	.07	.15	.08	.13	.14	.18
Total	.69	.82	.62	.59	.53	.36	.41	.70	.78	.74	.74
Nitrogen											
Soluble coagulable protein	.188	.253	.145	.145	.143	.059	.076	.138	.200	.251	.177
Soluble non-coagulable protein	.013	.021	.011	.009	.011	.010	.007	.011	.011	.012	.011
Total soluble protein	.201	.274	.156	.154	.154	.069	.083	.149	.211	.263	.188
Soluble non-protein	.179	.290	.175	.168	.158	.082	.100	.252	.241	.207	.203
Total soluble nitrogen	.380	.564	.331	.322	.312	.151	.183	.401	.452	.470	.391
Insoluble protein	2.222	2.206	1.717	1.714	1.596	1.250	1.321	2.021	2.283	2.340	2.429
Total nitrogen	2.602	2.770	2.048	2.036	1.908	1.401	1.504	2.422	2.735	2.810	2.820
Phosphorus											
Soluble inorganic	.076	.105	.069	.079	.069	.053	.056	.095	.088	.084	.091
Soluble organic	.013	.022	.016	.004	.010	.001	.001	.005	.022	.005	.008
Total soluble	.089	.127	.085	.083	.079	.054	.057	.100	.110	.089	.099
Insoluble	.055	.050	.054	.058	.049	.019	.047	.049	.047	.080	.008
Total phosphorus	.144	.177	.139	.141	.128	.073	.104	.149	.157	.149	.107

TABLE 6.—CHEMICAL COMPOSITION OF THE BONELESS MEAT OF THE FORE AND HIND QUARTERS, AND THE ENTIRE SIDES, EXPRESSED IN PERCENT

Constituents	Fore quarter			Hind quarter			Half carcass		
	Steer No. 1	Steer No. 2	Steer No. 3	Steer No. 1	Steer No. 2	Steer No. 3	Steer No. 1	Steer No. 2	Steer No. 3
Water	50.91	51.00	45.01	51.92	51.67	47.81	51.38	51.32	46.32
Dry substance									
Soluble	3.32	3.67	2.61	3.89	4.11	3.24	3.58	3.88	2.89
Insoluble	46.20	45.66	52.37	44.44	44.42	48.65	45.39	45.07	50.76
Total	49.52	49.33	54.98	48.33	48.53	51.99	48.97	48.95	58.65
Soluble protein									
Coagulable	1.21	1.34	.77	1.59	1.54	1.09	1.38	1.44	.92
Non-coagulable	.18	.12	.06	.12	.12	.09	.16	.12	.07
Total	1.39	1.46	.83	1.71	1.68	1.18	1.54	1.56	.99
Insoluble protein	12.42	12.67	10.87	12.50	12.81	11.59	12.46	12.74	11.12
Total protein	13.81	14.13	11.71	14.21	14.49	12.77	14.00	14.30	12.18
Organic extractives									
Nitrogenous	.67	.70	.55	.75	.81	.63	.71	.75	.59
Non-nitrogenous	.70	.92	.76	.84	1.00	.87	.77	.96	.81
Total	1.37	1.62	1.31	1.59	1.81	1.50	1.48	1.71	1.40
Fat	33.60	32.82	41.39	31.86	31.44	37.06	32.84	32.17	39.46
Ash									
Soluble	.56	.59	.46	.56	.63	.55	.58	.60	.50
Insoluble	.11	.18	.11	.08	.15	.10	.09	.17	.10
Total	.67	.77	.57	.66	.78	.65	.67	.77	.60

TABLE 7.—WEIGHTS OF CHEMICAL CONSTITUENTS OF THE BONELESS MEAT OF THE FORE AND HIND QUARTERS, AND THE ENTIRE SIDES, EXPRESSED IN KILOGRAMS[1]

Constituents	Fore quarter			Hind quarter			Half carcass		
	Steer No. 1	Steer No. 2	Steer No. 3	Steer No. 1	Steer No. 2	Steer No. 3	Steer No. 1	Steer No. 2	Steer No. 3
Total weight without bone	54.85	69.74	92.23	46.82	62.44	74.23	101.67	132.53	166.41
Water	27.92	35.57	41.51	24.31	32.26	35.49	52.23	67.83	77.10
Dry substance									
Soluble	1.82	2.56	2.41	1.82	2.56	2.40	3.64	5.12	4.81
Insoluble	25.34	31.85	48.30	20.81	27.73	36.19	46.15	59.58	84.50
Total	27.16	34.40	50.71	22.63	30.30	38.60	49.79	64.70	89.31
Soluble protein									
Coagulable	.66	.94	.71	.74	.96	.81	1.41	1.90	1.52
Non-coagulable	.10	.08	.05	.06	.08	.06	.16	.16	.12
Total	.76	1.02	.77	.80	1.05	.88	1.57	2.07	1.64
Insoluble protein	6.81	8.83	10.03	5.85	8.00	8.60	12.66	16.84	18.63
Total	7.58	9.85	10.80	6.65	9.05	9.48	14.23	18.90	20.28
Organic extractives									
Nitrogenous	.37	.49	.51	.35	.51	.47	.72	.99	.98
Non-nitrogenous	.38	.64	.70	.39	.62	.65	.78	1.27	1.34
Total	.75	1.13	1.21	.75	1.13	1.12	1.50	2.26	2.33
Fat	18.47	22.89	38.17	14.92	19.63	27.51	33.39	42.52	65.69
Ash									
Soluble	.31	.41	.43	.27	.39	.41	.58	.80	.84
Insoluble	.06	.12	.10	.04	.09	.07	.10	.22	.17
Total	.37	.53	.53	.31	.48	.48	.68	1.02	1.01

[1] One kilogram equals 2.2 pounds.

TABLE 8.—RATIO OF NON-PROTEIN TO PROTEIN NITROGEN IN THE BONELESS MEAT OF THE WHOLESALE CUTS

	Steer No. 1		Steer No. 2		Steer No. 3	
	In water extract	In meats	In water extract	In meats	In water extract	In meats
Hind shank	1: 1.09	1:10.20	1: 0.99	1: 9.70	1: 1.12	1:13.53
Round	1: 1.30	1: 9.30	1: 1.06	1: 8.40	1: 0.94	1: 8.55
Rump	1: 1.05	1: 9.40	1: 1.04	1: 9.80	1: 0.89	1:10.70
Loin	1: 0.99	1: 8.50	1: 1.04	1: 9.00	1: 0.92	1:11.11
Rib	1: 0.98	1: 9.60	1: 1.01	1:10.00	1: 0.97	1:11.07
Flank	1: 1.15	1:15.00	1: 0.90	1: 9.50	1: 0.84	1:16.08
Plate	1: 0.91	1:11.60	1: 0.95	1:10.80	1: 0.83	1:14.04
Chuck	1: 1.08	1: 9.90	1: 1.12	1: 9.80	1: 0.59	1: 8.61
Clod	1: 1.41	1:11.00	1: 0.94	1: 8.70	1: 0.88	1:10.34
Neck	1: 1.21	1:16.60	1: 1.08	1:10.40	1: 1.27	1:12.57
Fore shank	1: 0.94	1:10.60	1: 0.99	1:11.00	1: 0.93	1:14.86
Average	1: 1.02	1:11.10	1: 1.02	1: 9.70	1: 0.93	1:11.95

TABLE 9.—CHEMICAL COMPOSITION OF THE VISIBLE FAT FROM STEERS NOS. 1 AND 2, EXPRESSED IN PERCENT

	Calculated to the fresh substance					Calculated to water-free substance			
	Water	Protein	Ether extract	Ash	Nitrogen	Protein	Ether extract	Ash	Nitrogen
Steer No. 1	12.07	4.54	83.39	......	.726	5.17	94.83	......	.826
Steer No. 2	13.22	4.30	82.71	.20	.689	4.95	95.32	.23	.794

TABLE 10.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE LOIN, EXPRESSED IN POUNDS

Retail loin cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Sirloin steak (butt-end)	1.88	.59	.14	2.61	3.38	1.06	.33	4.85	3.88	1.42	.27	5.57
2. Sirloin steak (wedge-bone)	2.47	.62	.22	3.31	2.70	.88	.25	3.89	3.84	1.67	.36	5.87
3. Sirloin steak (round-bone)	2.39	1.14	.20	3.73	2.80	.83	.25	3.97	3.52	1.86	.25	5.63
4. Sirloin steak (round-bone)	2.14	1.32	.31	3.77	2.91	1.11	.34	4.42	3.62	1.61	.64	5.87
5. Sirloin steak (double-bone)	2.61	1.03	.53	4.17	3.10	1.20	.59	4.98	2.74	1.62	.89	5.25
6. Sirloin steak (double-bone)	2.15	.91	.36	3.42	3.04	.36	.59	4.08				
7. Sirloin steak (hip-bone)					2.14	1.16	.66	4.08	2.25	1.65	.75	4.71
8. Porterhouse steak	1.76	.86	.38	3.00	2.44	1.59	.57	4.74	2.37	1.63	.44	4.47
9. Porterhouse steak	1.65	.99	.14	2.78	2.08	1.42	.20	3.81	2.00	1.89	.30	4.22
10. Porterhouse steak	1.56	.97	.14	2.67	2.02	1.31	.22	3.61	1.94	1.89	.36	4.19
11. Porterhouse steak	1.48	.78	.16	2.42	1.92	1.12	.21	3.33				
12. Porterhouse steak	1.36	.64	.14	2.14	1.69	1.00	.17	2.92	1.62	1.50	.28	3.43
13. Porterhouse steak	1.23	.50	.11	1.84	1.80	.95	.23	3.06	1.53	1.80	.42	3.75
14. Porterhouse steak	1.19	.53	.17	1.89	1.36	.68	.24	2.36	1.40	1.46	.30	3.19
15. Porterhouse steak					1.13	.72	.14	2.02	1.28	1.37	.25	2.90
16. Club steak	.88	.48	.11	1.47	1.31	.78	.17	2.26	1.28	1.11	.23	2.65
17. Club steak	.98	.39	.21	1.58	1.44	.81	.28	2.58	1.45	1.47	.49	3.44
18. Club steak	1.08	.44	.26	1.78	1.44	.82	.17	2.49	1.47	1.47	.41	3.38
19. Trimmings (wholesale)									.19	1.75	.00	1.94
Entire loin	26.81	12.19	3.58	42.58	38.70	17.80	5.61	63.45	36.38	27.17	6.64	70.46

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[1] Includes loss and error.

TABLE 11.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE LOIN, EXPRESSED IN PERCENT

Retail loin cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Sirloin steak (butt-end)	72.03	22.61	5.36	100.00	69.69	21.86	6.80	98.35	69.66	25.49	4.85	100.00
2. Sirloin steak (wedge-bone)	74.62	18.74	6.64	100.00	69.41	22.62	6.43	98.46	65.42	28.45	6.13	100.00
3. Sirloin steak (round-bone)	64.07	30.56	5.37	100.00	70.53	20.91	6.30	97.74	62.52	33.04	4.44	100.00
4. Sirloin steak (round-bone)	56.77	35.01	8.22	100.00	65.84	25.11	7.70	98.65	61.67	27.43	10.90	100.00
5. Sirloin steak (double-bone)	62.59	24.70	12.71	100.00	62.25	24.10	11.85	98.20	52.19	30.86	16.95	100.00
6. Sirloin steak (double-bone)	62.87	26.61	10.52	100.00	74.51	8.83	14.46	97.80				
7. Sirloin steak (hip-bone)					52.45	28.43	16.18	97.06	47.77	35.03	15.92	98.72
8. Porterhouse steak	58.67	28.66	12.67	100.00	51.48	33.54	12.03	97.05	53.02	36.47	9.84	99.33
9. Porterhouse steak	59.35	35.61	5.04	100.00	54.59	37.27	5.25	97.11	47.39	44.79	7.11	99.29
10. Porterhouse steak	58.43	36.33	5.24	100.00	55.96	36.29	6.09	98.34	46.30	45.11	8.59	100.00
11. Porterhouse steak	61.16	32.23	6.61	100.00	57.66	33.63	6.31	97.60				
12. Porterhouse steak	63.55	29.91	6.54	100.00	57.88	34.25	5.82	97.75	47.23	43.73	8.16	99.12
13. Porterhouse steak	66.85	27.17	5.98	100.00	58.82	31.05	7.52	97.39	40.80	48.00	11.20	100.00
14. Porterhouse steak	62.97	28.04	8.99	100.00	57.63	28.81	10.17	96.61	43.89	45.77	9.40	99.06
15. Porterhouse steak					55.94	35.64	6.93	98.51	44.14	47.24	8.62	100.00
16. Club steak	59.87	32.65	7.48	100.00	57.96	34.51	7.52	99.99	48.30	41.89	8.68	98.87
17. Club steak	62.03	24.68	13.29	100.00	55.81	31.39	10.85	98.05	42.15	42.73	14.25	99.13
18. Club steak	60.67	24.72	14.61	100.00	57.83	32.93	6.83	97.59	43.79	43.40	12.13	99.71
19. Trimmings (wholesale)									9.79	90.21	0.	100.00
Entire loin	62.96	28.63	8.41	100.00	60.99	28.05	8.84	97.88	51.63	38.56	9.41	99.60

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[1] Includes loss and error.

TABLE 12.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE RIB, EXPRESSED IN POUNDS

Retail rib cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Roast (11th and 12th ribs)..	2.95	1.94	.89	5.78	4.22	2.92	.89	8.14	4.34	4.19	1.03	9.56
2. Roast (9th and 10th ribs)..	3.70	2.06	.91	6.67	5.41	2.62	1.17	9.30	5.28	3.78	1.69	10.75
3. Roast (7th and 8th ribs)..	4.56	1.77	1.44	7.77	5.80	2.83	1.42	10.17	6.47	4.06	1.84	12.37
4. Roast (6th rib)	4.03	1.17	1.11	6.31	5.25	1.89	.89	8.17	4.40	2.31	1.13	7.84
Entire rib	15.24	6.94	4.35	26.53	20.68	10.26	4.37	35.78	20.49	14.34	5.69	40.52

TABLE 13.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE RIB, EXPRESSED IN PERCENT

Retail rib cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Roast (11th and 12th ribs)..	51.04	33.56	15.40	100.00	51.84	35.87	11.06	98.77	45.43	43.78	10.78	100.00
2. Roast (9th and 10th ribs)..	55.47	30.89	13.64	100.00	58.17	28.17	12.58	98.92	49.13	35.17	15.70	100.00
3. Roast (7th and 8th ribs)..	58.69	22.78	18.53	100.00	57.03	27.83	13.96	98.82	52.27	32.83	14.90	100.00
4. Roast (6th rib)	63.87	18.54	17.59	100.00	64.26	23.13	10.89	98.28	56.18	29.48	14.34	100.00
Entire rib	57.44	26.16	16.40	100.00	57.80	28.67	12.21	98.68	50.57	35.39	14.04	100.00

TABLE 14.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE ROUND, EXPRESSED IN POUNDS

Retail round cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Rump roast	6.00	3.95	2.49	12.44	6.01	3.44	2.50	12.11	7.08	4.90	2.77	14.75
2. Round steak (first cut)	1.78	.30	.25	2.33	3.48	.42	.52	4.50	3.39	.83	.56	4.84
3. Round steak	1.86	.33	.23	2.42	3.70	.36	.38	4.55	3.65	.91	.47	5.03
4. Round steak	2.03	.15	.16	2.34	4.25	.45	.22	5.00	4.90	.82	.25	6.00
5. Round steak	2.20	.31	.11	2.62	4.39	.55	.14	5.17	4.90	1.00	.19	6.09
6. Round steak	2.12	.32	.08	2.52	4.00	.54	.12	4.79	5.65	1.38	.16	7.25
7. Round steak	1.97	.33	.06	2.36	3.83	.80	.11	4.85	5.03	1.53	.19	6.81
8. Round steak	2.26	.41	.06	2.73	3.61	.78	.14	4.61	4.31	1.50	.16	6.03
9. Round steak	2.21	.43	.06	2.70								
10. Round steak	1.86	.46	.06	2.38								
11. Round steak	1.91	.56	.08	2.55								
12. Round steak	1.68	.44	.08	2.20	3.14	.81	.14	4.61	4.03	1.53	.25	3.84
13. Round steak	1.58	.28	.09	1.95								
14. Round steak	1.67	.23	.13	2.03	2.95	.64	.17	3.86	3.17	1.05	.53	4.78
15. Knuckle soup bone	.98	.84	2.05	3.87	1.09	.30	3.42	4.91	.44	1.75	2.44	4.66
16. Pot roast	4.14	.42	0	4.56	7.16	.86	.11	8.21	5.79	1.52	.09	7.40
17. Shank soup bone	1.67	.27	1.58	3.52	1.34	.14	1.99	3.56	1.41	.90	1.69	4.00
18. Shank soup bone	1.36	.24	.45	2.05	2.23	.27	.61	3.16	2.37	.63	.72	3.72
19. Shank soup bone (hock)	.09	.03	2.46	2.58	.30	.23	3.09	3.70	.63	1.16	3.12	4.91
Entire round	39.37	10.30	10.48	60.15	51.48	10.59	13.66	77.12	56.75	21.41	13.59	92.11

[1] Includes loss and error.

TABLE 15.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE ROUND, EXPRESSED IN PERCENT

Retail round cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Rump roast	48.23	31.75	20.02	100.00	49.63	28.38	20.65	98.66	47.98	33.26	18.76	100.00
2. Round steak (first cut)	76.40	12.87	10.73	100.00	76.07	10.75	11.44	98.26	70.00	17.10	11.61	98.71
3. Round steak	76.86	13.64	9.50	100.00	81.43	7.93	8.24	97.60	72.67	18.01	9.32	100.00
4. Round steak	86.75	6.41	6.84	100.00	85.00	9.06	4.38	98.44	81.67	13.67	4.17	99.51
5. Round steak	83.97	11.83	4.20	100.00	84.89	10.57	2.72	98.18	80.51	16.41	3.08	100.00
6. Round steak	84.13	12.70	3.17	100.00	83.38	11.40	2.60	97.38	78.02	18.97	2.16	99.15
7. Round steak	83.48	13.98	2.54	100.00	79.04	16.42	2.27	97.73	73.85	22.48	2.75	99.08
8. Round steak	82.78	15.02	2.20	100.00	78.31	17.94	3.06	99.31	71.50	25.88	2.59	99.97
9. Round steak	81.85	15.93	2.22	100.00								
10. Round steak	78.15	19.33	2.52	100.00								
11. Round steak	74.90	21.96	3.14	100.00								
12. Round steak	76.36	20.00	3.64	100.00	75.85	19.64	3.40	98.39	68.99	26.20	4.28	99.47
13. Round steak	81.02	14.36	4.62	100.00								
14. Round steak	82.27	11.33	6.40	100.00	76.52	16.60	4.45	97.57	66.37	21.97	11.09	99.30
15. Knuckle soup bone	25.32	21.71	52.97	100.00	22.28	6.05	69.75	98.08	9.40	37.59	52.35	99.34
16. Pot roast	90.79	9.21	0	100.00	87.23	10.48	1.34	99.05	78.26	20.47	1.27	100.00
17. Shank soup bone	47.44	7.67	44.89	100.00	37.71	3.95	55.71	97.37	35.25	22.50	42.25	100.00
18. Shank soup bone	66.34	11.71	21.95	100.00	70.57	8.52	19.30	98.41	63.86	16.81	19.33	100.00
19. Shank soup bone (hock)	3.49	1.16	95.35	100.00	8.02	6.35	83.54	97.91	12.74	23.57	63.69	100.00
Entire round	65.46	17.12	17.42	100.00	66.75	13.73	17.71	98.19	61.61	23.24	14.75	99.60

[1] Includes loss and error.

TABLE 16.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE CHUCK, EXPRESSED IN POUNDS

Retail chuck cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Roast (5th rib)	4.09	.85	.97	5.91	4.48	1.70	1.02	7.31	5.78	2.31	1.28	9.38
2. Chuck steak	1.45	.36	.50	2.31	2.70	.77	.58	4.14	1.87	.72	.62	3.21
3. Chuck steak	1.84	.22	.25	2.31	2.98	.63	.47	4.14	1.52	1.36	.34	3.22
4. Chuck steak	1.84	.22	.27	2.33	3.19	.56	.46	4.27	2.23	.89	.41	3.56
5. Chuck steak	2.08	.30	.46	2.84	3.06	.66	.37	4.19	2.61	.97	.51	4.12
6. Chuck steak	1.98	.31	.23	2.52	3.61	.51	.48	4.66	3.28	.91	.44	4.63
7. Chuck steak	2.25	.23	.44	2.92	3.16	.46	.35	4.06	3.88	.00	.37	4.25
8. Chuck steak	2.44	.24	.34	3.02	3.13	.45	.34	3.98	2.70	.86	.44	4.00
9. Chuck steak	2.28	.25	.31	2.84	3.37	.48	.49	4.45	2.75	.97	.31	4.03
10. Pot roast	3.92	.53	.38	4.83	4.45	1.02	1.04	6.67	6.41	1.37	.25	8.03
11. Pot roast	4.92	1.94	1.34	8.20	3.64	2.37	.61	6.81	8.63	2.94	2.31	13.94
12. Pot roast	3.33	.44	.92	4.69	4.48	.27	.36	5.14	7.31	1.22	1.09	9.62
13. Stew	2.86	1.78	.03	4.67	4.63	1.19	.67	6.55	4.91	4.40	.41	9.72
14. Clod	3.45	.55	.22	4.22	4.76	.58	.25	5.64	4.74	1.29	.28	6.31
15. Neck	5.23	1.93	1.09	8.25	3.33	1.15	.44	5.06	1.84	.72	.97	3.53
Entire chuck	43.96	10.15	7.75	61.86	54.97	12.80	7.93	77.07	60.46	20.93	10.03	91.55

[1] Includes loss and error.

TABLE 17.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE CHUCK, EXPRESSED IN PERCENT

Retail chuck cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Roast (5th rib)	69.21	14.38	16.41	100.00	61.32	23.30	13.88	98.50	61.67	24.67	13.66	100.00
2. Chuck steak	62.77	15.58	21.65	100.00	65.30	18.49	13.94	97.73	58.25	22.34	19.41	100.00
3. Chuck steak	79.65	9.53	10.82	100.00	72.06	15.09	11.32	98.47	47.08	42.23	10.69	100.00
4. Chuck steak	78.97	9.44	11.59	100.00	74.72	13.00	11.00	98.72	62.64	25.00	11.52	99.16
5. Chuck steak	73.24	10.56	16.20	100.00	73.13	15.69	8.94	97.76	63.35	23.54	12.38	99.27
6. Chuck steak	78.57	12.30	9.13	100.00	77.52	10.73	10.40	98.65	70.84	19.66	9.50	100.00
7. Chuck steak	77.05	7.88	15.07	100.00	78.06	11.35	8.47	97.88	91.18	0	8.82	100.00
8. Chuck steak	80.79	7.95	11.26	100.00	78.43	11.37	8.63	98.43	67.58	21.48	10.94	100.00
9. Chuck steak	80.28	8.80	10.92	100.00	75.77	10.87	10.89	97.53	68.22	24.03	7.75	100.00
10. Pot roast	81.16	10.97	7.87	100.00	66.76	15.22	15.69	97.67	79.77	17.12	3.11	100.00
11. Pot roast	60.00	23.66	16.34	100.00	53.45	34.85	8.95	97.25	61.91	21.09	16.51	99.51
12. Pot roast	71.00	9.38	19.62	100.00	87.22	5.17	7.00	99.39	75.97	12.66	11.37	100.00
13. Stew	61.24	38.12	.64	100.00	70.64	18.13	10.27	99.04	50.48	45.34	4.18	100.00
14. Clod	81.76	13.03	5.21	100.00	84.40	10.28	4.43	99.11	75.00	20.55	4.45	100.00
15. Neck	63.39	23.28	13.33	100.00	65.81	22.73	8.69	97.23	52.21	20.36	27.43	100.00
Entire chuck	71.06	16.41	12.53	100.00	71.32	16.61	10.29	98.22	66.04	22.86	10.96	99.86

[1] Includes loss and error.

TABLE 18.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE PLATE, EXPRESSED IN POUNDS

Retail plate cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Brisket, boiling or corning piece	8.32	4.94	1.05	14.31	11.44	8.78	1.72	22.00	13.91	11.72	2.28	27.91
2. Navel, stew	6.47	4.12	1.19	11.78	10.31	5.01	1.18	16.50	12.06	11.84	1.66	25.56
3. Rib ends	2.69	1.95	.66	5.30	2.99	1.39	.64	5.16	2.44	2.97	.75	6.16
4. Rib ends	3.47	1.55	.92	5.94	3.60	2.05	.75	6.49	3.22	4.31	.84	8.37
5. Trimmings (wholesale)	0	2.80	0	2.80	.75	1.05	0	1.80	0	4.50	0	4.50
Entire plate	20.95	15.36	3.82	40.13	29.09	18.28	4.29	51.95	31.65	35.34	5.53	72.50

TABLE 19.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE PLATE, EXPRESSED IN PERCENT

Retail plate cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Brisket, boiling or corning piece	58.14	34.52	7.34	100.00	52.00	39.91	7.82	99.73	49.84	41.99	8.17	100.00
2. Navel, stew	54.92	34.98	10.10	100.00	62.48	30.36	7.15	100.00	47.19	46.33	6.48	100.00
3. Rib ends	50.76	36.79	12.45	100.00	57.95	26.94	12.40	97.29	39.61	48.21	12.18	100.00
4. Rib ends	58.42	26.09	15.49	100.00	55.47	31.59	11.56	98.62	38.47	51.49	10.04	100.00
5. Trimmings (wholesale)	0	100.00	0	100.00	41.67	58.33	0	100.00	0	100.00	0	100.00
Entire plate	52.21	38.27	9.52	100.00	55.99	35.19	8.26	99.44	43.63	48.74	7.63	100.00

[1] Includes loss and error.

TABLE 20.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE FLANK, EXPRESSED IN POUNDS

Retail flank cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Stew	4.43	2.02	.02	6.47	5.83	2.31	.06	8.30	4.59	3.88	.06	8.56
2. Flank steak	1.37	.22	0	1.59	1.65	.30	0	1.98	1.47	.37	0	1.84
3. Trimmings (wholesale)	0	6.47	0	6.47	.10	8.92	0	9.02	0	10.00	0	10.00
Entire flank	5.80	8.71	.02	14.53	7.58	11.53	.06	19.30	6.06	14.25	.06	20.40

TABLE 21.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE FLANK, EXPRESSED IN PERCENT

Retail flank cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Stew	68.47	31.22	.31	100.00	70.24	27.83	.72	98.79	53.62	45.33	.70	99.65
2. Flank steak	86.17	13.83	0	100.00	83.33	15.15	0	98.48	79.66	20.34	0	100.00
3. Trimmings (wholesale)	0	100.00	0	100.00	1.11	98.89	0	100.00	0	100.00	0	100.00
Entire flank	39.92	59.94	.14	100.00	39.27	59.74	.31	99.32	29.71	69.85	.29	99.85

[1] Includes loss and error.

TABLE 22.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE FORE SHANK, EXPRESSED IN POUNDS

Retail shank cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Stew	2.91	.53	0	3.44	2.75	.34	0	3.12	4.50	1.50	0	6.00
2. Soup bone (knuckle)........	.76	.16	1.47	2.39	1.06	.27	2.22	3.64	1.19	.84	2.34	4.37
3. Soup bone	.33	.06	.67	1.06	.88	.30	1.42	2.66	.31	.25	1.00	1.56
4. Soup bone	.97	.27	1.37	2.61	1.36	.31	.94	2.64	1.18	.66	1.97	3.81
5. Soup bone	1.53	.11	.52	2.16	1.69	.05	.62	2.38	1.84	.28	.72	2.84
6. Soup bone	.70	.02	1.55	2.27	.12	0	1.89	2.06	.53	2.63	2.22	3.38
Entire fore shank..............	7.20	1.15	5.58	13.93	7.86	1.27	7.09	16.50	9.55	4.16	8.25	21.96

TABLE 23.—LEAN, VISIBLE FAT, AND BONE IN THE RETAIL CUTS OF THE FORE SHANK, EXRESSED IN PERCENT

Retail shank cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Stew	84.59	15.41	0	100.00	88.14	10.89	0	99.03	75.00	25.00	0	100.00
2. Soup bone (knuckle)........	31.80	6.70	61.50	100.00	29.12	7.42	60.99	97.53	27.23	19.22	53.55	100.00
3. Soup bone	31.13	5.66	63.21	100.00	33.08	11.28	53.38	97.74	19.87	16.02	64.11	100.00
4. Soup bone	37.16	10.34	52.50	100.00	51.52	11.74	35.61	98.87	30.97	17.32	51.71	100.00
5. Soup bone	70.83	5.09	24.08	100.00	71.01	2.10	26.05	99.16	64.79	9.87	25.34	100.00
6. Soup bone	30.84	.88	68.28	100.00	5.77	0	90.87	96.64	15.68	18.64	65.68	100.00
Entire fore shank..............	51.69	8.25	40.06	100.00	47.64	7.69	42.97	98.30	43.49	18.94	37.57	100.00

[1] Includes loss and error.

TABLE 24.—LEAN, FAT, AND BONE IN THE TRIMMED RETAIL CUTS OF THE LOIN, EXPRESSED IN POUNDS

Retail loin cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Sirloin steak (butt-end).....	1.88	.34	.05	2.27	3.36	.62	.08	4.11	3.88	1.25	.25	5.38
2. Sirloin steak (wedge-bone)..	2.47	.36	.20	3.03	2.70	.69	.17	3.62	3.84	1.38	.31	5.53
3. Sirloin steak (round-bone)..	2.39	.87	.20	3.46	2.80	.64	.22	3.70	3.44	1.53	.16	5.13
4. Sirloin steak (round-bone)..	2.14	.96	.20	3.30	2.89	.86	.22	4.00	3.59	1.41	.50	5.50
5. Sirloin steak (double-bone)..	2.61	.69	.30	3.60	3.02	.86	.34	4.28	2.69	.87	.50	4.06
6. Sirloin steak (double-bone)..	2.15	.52	.27	2.94	3.02	0	.47	3.56				
7. Sirloin steak (hip-bone).....					2.11	.61	.55	3.38	2.22	.84	.56	3.62
8. Porterhouse steak	1.76	.58	.33	2.67	2.42	.92	.52	3.97	2.37	.72	.44	3.53
9. Porterhouse steak	1.65	.77	.14	2.56	2.08	.89	.17	3.23	2.00	.97	.19	3.16
10. Porterhouse steak	1.56	.80	.14	2.50	2.02	.92	.22	3.22	1.94	.97	.25	3.16
11. Porterhouse steak	1.48	.64	.16	2.28	1.92	.87	.19	3.06				
12. Porterhouse steak	1.36	.64	.14	2.14	1.69	.78	.17	2.70	1.62	.94	.16	2.72
13. Porterhouse steak	1.23	.50	.11	1.84	1.80	.73	.23	2.84	1.53	.94	.28	2.75
14. Porterhouse steak	1.19	.53	.17	1.89	1.36	.45	.24	2.13	1.40	.88	.19	2.47
15. Porterhouse steak					1.15	.61	.14	1.91	1.28	.65	.16	2.09
16. Club steak	.88	.48	.11	1.47	1.31	.67	.17	2.15	1.28	.59	.12	1.99
17. Club steak	.98	.38	.16	1.52	1.44	.64	.28	2.41	1.44	.81	.38	2.63
18. Club steak	1.08	.42	.20	1.70	1.44	.52	.17	2.19	1.47	.75	.28	2.50
Entire trimmed loin............	26.81	9.48	2.88	39.17	38.51	12.28	4.55	56.46	35.99	15.50	4.73	56.22

[1] Includes loss and error.

TABLE 25.—LEAN, VISIBLE FAT, AND BONE IN THE TRIMMED RETAIL CUTS OF THE LOIN, EXPRESSED IN PERCENT

Retail loin cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Sirloin steak (butt-end).....	82.82	14.98	2.20	100.00	81.75	15.09	1.95	98.79	72.12	23.23	4.65	100.00
2. Sirloin steak (wedge-bone)..	81.52	11.88	6.60	100.00	74.59	19.06	4.70	98.35	69.44	24.96	5.60	100.00
3. Sirloin steak (round-bone)..	69.08	25.14	5.78	100.00	75.68	17.30	5.95	98.93	67.06	29.82	3.12	100.00
4. Sirloin steak (round-bone)..	64.85	29.09	6.06	100.00	72.25	21.50	5.50	99.25	65.27	25.64	9.09	100.00
5. Sirloin steak (double-bone)..	72.50	19.17	8.33	100.00	70.56	20.09	7.94	98.59	66.26	21.43	12.31	100.00
6. Sirloin steak (double-bone)..	73.13	17.69	9.18	100.00	84.83	0	13.21	98.04				
7. Sirloin steak (hip-bone).....					62.43	18.05	16.27	96.75	61.33	23.20	15.47	100.00
8. Porterhouse steak	65.92	21.72	12.36	100.00	60.06	23.17	13.10	97.23	67.14	20.40	12.46	100.00
9. Porterhouse steak	64.45	30.08	5.47	100.00	64.40	27.55	5.26	97.21	63.29	30.70	6.01	100.00
10. Porterhouse steak	62.40	32.00	5.60	100.00	62.73	28.57	6.83	98.13	61.39	30.70	7.91	100.00
11. Porterhouse steak	64.91	28.07	7.02	100.00	62.75	28.43	6.21	97.39				
12. Porterhouse steak	63.55	29.91	6.54	100.00	62.59	28.89	6.30	97.78	59.56	34.56	5.88	100.00
13. Porterhouse steak	66.85	27.17	5.98	100.00	63.38	25.70	8.10	97.18	55.64	34.18	10.18	100.00
14. Porterhouse steak	62.97	28.04	8.99	100.00	63.85	21.13	11.27	96.25	56.68	35.63	7.69	100.00
15. Porterhouse steak					59.16	31.94	7.33	98.43	61.24	31.10	7.66	100.00
16. Club steak	59.87	32.65	7.48	100.00	60.93	31.16	7.91	100.00	64.32	29.65	6.03	100.00
17. Club steak	64.47	25.00	10.53	100.00	59.75	26.56	11.62	97.93	54.75	30.80	14.45	100.00
18. Club steak	63.53	24.71	11.76	100.00	65.75	23.74	7.76	97.25	58.80	30.00	11.20	100.00
Entire trimmed loin............	68.45	24.20	7.35	100.00	68.21	21.75	8.06	98.02	64.02	27.57	8.41	100.00

TABLE 26.—AVERAGE PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE TRIMMED RETAIL CUTS OF THE THREE LOINS

Retail loin cuts	Lean	Fat	Bone	Total
1. Sirloin steak (butt-end)	78.90	17.77	2.93	99.60
2. Sirloin steak (wedge-bone)	75.18	18.63	5.63	99.44
3. Sirloin steak (round-bone)	70.61	24.09	4.95	99.65
4. Sirloin steak (round-bone)	67.46	25.40	6.88	99.74
5. Sirloin steak (double-bone)	69.77	20.23	9.53	99.53
6. Sirloin steak (double-bone)[1]	78.98	8.85	11.19	99.02
7. Sirloin steak (hip-bone)[2]	61.88	20.63	15.87	98.38
8. Porterhouse steak	64.76	21.76	12.64	99.16
9. Porterhouse steak	64.05	29.44	5.58	99.07
10. Porterhouse steak	62.17	30.42	6.78	99.37
11. Porterhouse steak	63.83	28.25	6.61	98.69
12. Porterhouse steak	61.90	31.12	6.24	99.26
13. Porterhouse steak	61.96	29.02	8.09	99.07
14. Porterhouse steak	61.17	28.27	9.32	98.76
15. Porterhouse steak	60.20	31.52	7.50	99.22
16. Club steak	61.71	31.15	7.14	100.00
17. Club steak	59.66	27.45	12.20	99.31
18. Club steak	62.69	26.15	10.24	99.08
Entire trimmed loin	66.89	24.51	7.94	99.34

[1] This cut was made from the loins of Steers Nos. 1 and 2 only.

[2] This cut was made from the loins of Steers Nos. 2 and 3 only.

TABLE 27.—LEAN, VISIBLE FAT, AND BONE IN THE TRIMMED RETAIL CUTS OF THE ROUND, EXPRESSED IN POUNDS

Retail round cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Rump roast................	6.00	3.14	.58	9.72	5.87	2.53	.67	9.20	4.60	2.84	.25	7.69
2. Round steak (first cut)......	1.78	.16	0	1.94	3.36	.36	.11	3.89	3.09	.47	0	3.56
3. Round steak	1.86	.22	.11	2.19	3.70	.33	.38	4.52	3.65	.91	.47	5.03
4. Round steak	2.03	.09	.16	2.28	4.25	.36	.22	4.91	4.90	.63	.25	5.78
5. Round steak	2.20	.22	.11	2.53	4.39	.30	.14	4.92	4.90	.72	.19	5.81
6. Round steak	2.12	.19	.08	2.39	4.00	.37	.12	4.62	5.65	.88	.16	6.69
7. Round steak	1.97	.22	.06	2.25	3.83	.61	.11	4.66	5.03	1.03	.19	6.25
8. Round steak	2.26	.30	.06	2.62	3.61	.66	.14	4.49	4.31	1.25	.16	5.72
9. Round steak	2.21	.34	.06	2.61								
10. Round steak	1.86	.33	.06	2.25								
11. Round steak	1.91	.52	.08	2.51								
12. Round steak	1.68	.36	.08	2.12	3.14	.70	.14	4.03	4.00	1.31	.25	5.56
13. Round steak	1.58	.25	.09	1.92								
14. Round steak	1.67	.20	.13	2.00	2.95	.64	.17	3.86	2.75	.81	.19	3.75
15. Knuckle soup bone...........	.98	.84	2.05	3.87	1.09	.30	3.42	4.91	.44	1.59	2.44	4.47
16. Pot roast	4.14	.42	0	4.56	7.16	.86	.11	8.21	5.56	1.25	.09	6.90
17. Shank soup bone.............	1.67	.27	1.58	3.52	1.34	.14	1.99	3.56	1.41	.90	1.69	4.00
18. Shank soup bone.............	1.36	.24	.45	2.05	2.23	.27	.61	3.16	2.37	.63	.72	3.72
19. Shank soup bone (hock).....	.09	.03	2.46	2.58	.30	.23	3.09	3.70	.63	1.16	3.12	4.91
Entire trimmed round...........	39.37	8.34	8.20	55.91	51.22	8.66	11.42	72.64	53.29	16.38	10.17	79.81

[1] Includes loss and error.

TABLE 28.—LEAN, VISIBLE FAT, AND BONE IN THE TRIMMED RETAIL CUTS OF THE ROUND, EXPRESSED IN PERCENT

Retail round cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Rump roast	61.73	32.30	5.97	100.00	63.80	27.50	7.28	98.58	59.82	36.93	3.25	100.00
2. Round steak (first cut)	91.75	8.25	0	100.00	86.38	9.25	2.83	98.46	86.80	13.20	0	100.00
3. Round steak	84.93	10.05	5.02	100.00	81.86	7.30	8.41	97.57	72.57	18.09	9.34	100.00
4. Round steak	89.04	3.95	7.01	100.00	86.56	7.33	4.48	98.37	84.78	10.90	4.32	100.00
5. Round steak	86.96	8.70	4.34	100.00	89.23	6.10	2.85	98.18	84.34	12.39	3.27	100.00
6. Round steak	88.70	7.95	3.45	100.00	86.58	8.01	2.60	97.19	84.45	13.15	2.40	100.00
7. Round steak	87.56	9.78	2.66	100.00	82.19	13.09	2.36	97.64	80.48	16.48	3.04	100.00
8. Round steak	86.26	11.45	2.29	100.00	80.40	14.70	3.12	98.22	75.35	21.85	2.80	100.00
9. Round steak	84.67	13.03	2.30	100.00								
10. Round steak	82.67	14.67	2.66	100.00								
11. Round steak	76.10	20.72	3.18	100.00								
12. Round steak	79.25	16.98	3.77	100.00	77.92	17.37	3.47	98.76	71.94	23.56	4.50	100.00
13. Round steak	82.29	13.02	4.69	100.00								
14. Round steak	83.50	10.00	6.50	100.00	76.42	16.58	4.40	97.40	73.33	21.60	5.07	100.00
15. Knuckle soup bone	25.32	21.71	52.97	100.00	22.20	6.11	69.65	97.96	9.84	35.57	54.59	100.00
16. Pot roast	90.79	9.21	0	100.00	87.21	10.48	1.34	99.03	80.58	18.12	1.30	100.00
17. Shank soup bone	47.44	7.67	44.89	100.00	37.64	3.93	55.89	97.46	35.25	22.50	42.25	100.00
18. Shank soup bone	66.34	11.71	21.95	100.00	70.57	8.54	19.30	98.41	63.71	16.94	19.35	100.00
19. Shank soup bone (hock)	3.49	1.16	95.35	100.00	8.11	6.22	80.81	95.13	12.83	23.63	63.54	100.00
Entire trimmed round	70.42	14.92	14.66	100.00	70.51	11.92	15.72	98.15	66.75	20.52	12.73	100.00

TABLE 29.—AVERAGE PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE TRIMMED RETAIL CUTS OF THE THREE ROUNDS

Retail round cuts	Lean	Fat	Bone	Total
1. Rump roast	61.78	32.24	5.50	99.52
2. Round steak (first cut)	88.31	10.23	.94	99.48
3. Round steak	79.79	11.81	7.59	99.19
4. Round steak	86.79	7.39	5.27	99.45
5. Round steak	86.84	9.06	3.49	99.39
6. Round steak	86.58	9.70	2.82	99.10
7. Round steak	83.41	13.12	2.69	99.22
8. Round steak	80.67	16.00	2.74	99.41
9. Round steak[1]	84.67	13.03	2.30	100.00
10. Round steak[1]	82.67	14.67	2.66	100.00
11. Round steak[1]	76.10	20.72	3.18	100.00
12. Round steak	76.37	19.30	3.91	99.58
13. Round steak[1]	82.29	13.02	4.69	100.00
14. Round steak	77.75	16.06	5.32	99.13
15. Knuckle soup bone	19.12	21.13	59.07	99.32
16. Pot roast	86.19	12.60	.88	99.67
17. Shank soup bone	40.11	11.37	47.68	99.16
18. Shank soup bone	66.92	12.35	20.19	99.46
19. Shank soup bone (hock)	8.14	10.34	79.90	98.38
Entire trimmed round	69.23	15.79	14.37	99.39

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[1] This cut was made from the round of Steer No. 1 only.

TABLE 30.—LEAN, VISIBLE FAT, AND BONE IN THE TRIMMED RETAIL CUTS OF THE CHUCK, EXPRESSED IN POUNDS

Retail chuck cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Roast (5th rib)	4.03	.80	.81	5.64	4.36	1.64	.75	6.84	5.69	2.31	1.16	9.16
2. Chuck steak	1.39	.34	.27	2.00	2.64	.75	.49	3.97	1.84	.66	.53	3.03
3. Chuck steak	1.83	.20	.22	2.25	2.89	.58	.36	3.91	1.50	1.31	.16	2.97
4. Chuck steak	1.81	.22	.19	2.22	3.14	.55	.40	4.14	2.22	.84	.38	3.44
5. Chuck steak	2.03	.30	.29	2.62	3.00	.64	.30	4.02	2.56	.94	.28	3.78
6. Chuck steak	1.96	.31	.17	2.44	3.55	.49	.42	4.52	3.28	.88	.28	4.44
7. Chuck steak	2.19	.22	.25	2.66	3.12	.45	.27	3.92	3.88	0	.37	4.25
8. Chuck steak	2.39	.24	.28	2.91	3.08	.45	.31	3.92	2.69	.81	.22	3.72
9. Chuck steak	2.22	.25	.25	2.72	3.28	.45	.30	4.11	2.75	.97	.31	4.03
10. Pot roast	3.92	.53	.38	4.83	4.06	.97	.56	5.69	6.41	1.37	.25	8.03
11. Pot roast	4.78	1.44	.72	6.94	3.44	.90	.61	5.11	7.97	1.25	1.72	10.94
12. Pot roast	3.33	.44	.92	4.69	4.48	.27	.36	5.14	7.31	1.22	1.09	9.62
13. Stew	2.14	.19	.03	2.36	4.63	1.19	.67	6.55	4.91	4.40	.41	9.72
14. Clod	3.45	.55	.22	4.22	4.76	.58	.25	5.64	4.63	1.09	.28	6.00
15. Neck	3.65	.28	.58	4.51	2.39	.64	0	3.06	1.84	.72	.97	3.53
Entire trimmed chuck	41.12	6.31	5.58	53.01	52.82	10.55	6.15	70.54	59.48	18.77	8.41	86.66

TABLE 31.—LEAN, VISIBLE FAT, AND BONE IN THE TRIMMED RETAIL CUTS OF THE CHUCK, EXPRESSED IN PERCENT

Retail chuck cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Roast (5th rib)	71.45	14.19	14.36	100.00	63.74	23.97	10.97	98.68	62.12	25.22	12.66	100.00
2. Chuck steak	69.50	17.00	13.50	100.00	66.50	18.88	12.34	97.21	60.73	21.78	17.49	100.00
3. Chuck steak	80.88	8.88	9.73	99.49	73.91	14.83	9.20	97.94	50.51	44.11	5.38	100.00
4. Chuck steak	81.53	9.91	8.56	100.00	75.84	13.28	9.66	98.78	64.53	24.42	11.05	100.00
5. Chuck steak	77.48	11.46	11.06	100.00	74.62	15.92	7.46	98.00	67.72	24.87	7.41	100.00
6. Chuck steak	80.33	12.71	6.96	100.00	78.53	10.84	9.29	98.66	73.87	19.82	6.31	100.00
7. Chuck steak	82.34	8.27	9.39	100.00	79.59	11.48	6.89	97.96	91.29	0.00	8.71	100.00
8. Chuck steak	82.13	8.25	9.62	100.00	78.57	11.48	7.91	97.95	72.31	21.78	5.91	100.00
9. Chuck steak	81.62	9.19	9.19	100.00	79.81	10.95	7.30	98.06	68.24	24.07	7.69	100.00
10. Pot roast	81.16	10.97	7.87	100.00	71.35	17.05	9.84	98.24	79.83	17.06	3.11	100.00
11. Pot roast	68.87	20.75	10.38	100.00	67.32	17.61	11.94	96.87	72.85	11.43	15.72	100.00
12. Pot roast	71.00	9.39	19.61	100.00	87.16	5.29	7.00	99.45	75.99	12.68	11.33	100.00
13. Stew	90.68	8.05	1.27	100.00	70.69	18.17	10.23	99.09	50.51	45.27	4.22	100.00
14. Clod	81.76	13.03	5.21	100.00	84.40	10.28	4.52	99.20	77.17	18.17	4.66	100.00
15. Neck	80.93	6.20	12.87	100.00	78.10	20.92	0.00	99.02	52.12	20.40	27.48	100.00
Entire trimmed chuck	77.57	11.90	10.53	100.00	74.88	14.96	8.72	98.56	68.64	21.66	9.70	100.00

TABLE 32.—AVERAGE PERCENTAGES OF LEAN, VISIBLE FAT, AND BONE IN THE TRIMMED RETAIL CUTS OF THE THREE CHUCKS

Retail chuck cuts	Lean	Fat	Bone	Total
1. Roast (5th rib)	65.77	21.13	12.66	99.56
2. Chuck steak	65.57	19.22	14.44	99.07
3. Chuck steak	68.58	22.61	8.10	99.14
4. Chuck steak	73.97	15.87	9.76	99.60
5. Chuck steak	73.27	17.42	8.64	99.33
6. Chuck steak	77.58	14.46	7.52	99.56
7. Chuck steak	84.41	6.58	8.33	99.32
8. Chuck steak	77.67	13.84	7.81	99.32
9. Chuck steak	76.56	14.74	8.06	99.36
10. Pot roast	77.45	15.03	6.94	99.42
11. Pot roast	69.68	16.60	12.68	98.96
12. Pot roast	78.05	9.11	12.65	99.81
13. Stew	70.63	23.83	5.24	99.70
14. Clod	81.11	13.83	4.80	99.74
15. Neck	70.38	15.84	13.45	99.67
Entire trimmed chuck	73.70	16.17	9.65	99.52

TABLE 33.—LEAN, VISIBLE FAT, AND BONE IN TRIMMINGS FROM THE RETAIL CUTS OF THE LOIN, EXPRESSED IN POUNDS

Retail loin cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]
1. Sirloin steak (butt-end).....	0	.25	.09	.34	.02	.44	.25	.74	0	.17	.02	.19
2. Sirloin steak (wedge-bone)..	0	.26	.02	.28	0	.19	.08	.27	0	.29	.05	.34
3. Sirloin steak (round-bone)..	0	.27	0	.27	0	.19	.03	.27	.08	.33	.09	.50
4. Sirloin steak (round-bone)..	0	.36	.11	.47	.02	.25	12	.42	.03	.20	.14	.37
5. Sirloin steak (double-bone)..	0	.34	.23	.57	.08	.34	.25	.70	.05	.75	.39	1.19
6. Sirloin steak (double-bone).	0	.39	.09	.48	.02	.36	.12	.52				
7. Sirloin steak (hip-bone)....					.03	.55	.11	.70	.03	.81	.19	1.03
8. Porterhouse steak	0	.28	.05	.33	.02	.67	.05	.77	0	.91	0	.91
9. Porterhouse steak	0	.22	0	.22	0	.53	.03	.58	0	.92	.11	1.03
10. Porterhouse steak	0	.17	0	.17	0	.39	0	.39	0	.92	.11	1.03
11. Porterhouse steak	0	.14	0	.14	0	.25	.02	.27				
12. Porterhouse steak	0	0	0	0	0	.22	0	.22	0	.56	.12	.68
13. Porterhouse steak	0	0	0	0	0	.22	0	.22	0	.86	.14	1.00
14. Porterhouse steak	0	0	0	0	0	.23	0	.23	0	.58	.11	.69
15. Porterhouse steak					0	.11	0	.11	0	.72	.09	.81
16. Club steak	0	0	0	0	0	.11	0	.11	0	.52	.11	.63
17. Club steak	0	.01	.05	.0	0	.17	0	.17	.01	.66	.11	.78
18. Club steak	0	.02	.06	.0	0	.30	0	.30	0	.72	.13	.85
Total loin trimmings...........	0	2.71	.70	3.41	.19	5.52	1.06	6.99	.20	9.92	1.91	12.03

[1] Includes loss and error.

TABLE 34.—LEAN, VISIBLE FAT, AND BONE IN THE TRIMMINGS FROM THE RETAIL CUTS OF THE LOIN, EXPRESSED IN PERCENT

Retail loin cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Sirloin steak (butt end).....	0	73.53	26.47	100.00	2.70	59.45	33.78	95.93	0	89.47	10.53	100.00
2. Sirloin steak (wedge-bone)..	0	92.86	7.14	100.00	0	70.37	29.63	100.00	0	85.29	14.71	100.00
3. Sirloin steak (round-bone)..	0	100.00	0	100.00	0	70.37	11.11	81.48	16.00	66.00	18.00	100.00
4. Sirloin steak (round-bone)..	0	76.60	23.40	100.00	4.76	59.52	28.57	92.86	8.11	54.05	37.84	100.00
5. Sirloin steak (double-bone)..	0	59.65	40.35	100.00	11.43	48.57	35.71	95.71	4.20	63.03	32.77	100.00
6. Sirloin steak (double-bone)..	0	81.25	18.75	100.00	3.85	69.23	23.08	96.16				
7. Sirloin steak (hip-bone).....					4.29	78.57	15.71	98.57	2.91	78.64	18.45	100.00
8. Porterhouse steak	0	84.85	15.15	100.00	2.60	87.01	6.49	96.10	0	100.00	0	100.00
9. Porterhouse steak	0	100.00	0	100.00	0	91.38	5.17	96.55	0	89.32	10.68	100.00
10. Porterhouse steak	0	100.00	0	100.00	0	100.00	0	100.00	0	89.32	10.68	100.00
11. Porterhouse steak	0	100.00	0	100.00	0	92.59	7.41	100.00				
12. Porterhouse steak	0	0	0	0	0	100.00	0	100.00	0	82.35	17.65	100.00
13. Porterhouse steak	0	0	0	0	0	100.00	0	100.00	0	86.00	14.00	100.00
14. Porterhouse steak	0	0	0	0	0	100.00	0	100.00	0	84.06	15.94	100.00
15. Porterhouse steak					0	100.00	0	100.00	0	88.89	11.11	100.00
16. Club steak	0	0	0	0	0	100.00	0	100.00	0	82.54	17.46	100.00
17. Club steak	0	16.67	83.33	100.00	0	100.00	0	100.00	1.28	84.62	14.10	100.00
18. Club steak	0	25.00	75.00	100.00	0	100.00	0	100.00	0	84.71	15.29	100.00
Total loin trimmings............	0	79.47	20.53	100.00	2.72	78.97	15.16	96.85	1.66	82.46	15.88	100.00

TABLE 35.—LEAN, VISIBLE FAT, AND BONE IN TRIMMINGS FROM THE RETAIL CUTS OF THE ROUND, EXPRESSED IN POUNDS

Retail round cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Rump roast	0	.81	1.91	2.72	.14	.91	1.83	2.91	2.48	2.06	2.52	7.06
2. Round steak (first cut)	0	.14	.25	.39	.12	.06	.41	.61	.30	.36	.56	1.22
3. Round steak	0	.11	.12	.23	0	.03	0	.03	0	0	0	0
4. Round steak	0	.06	0	.06	0	.09	0	.09	0	.19	0	.19
5. Round steak	0	.09	0	.09	0	.25	0	.25	0	.28	0	.28
6. Round steak	0	.13	0	.13	0	.17	0	.17	0	.50	0	.50
7. Round steak	0	.11	0	.11	0	.19	0	.19	0	.50	0	.50
8. Round steak	0	.11	0	.11	0	.12	0	.12	0	.25	0	.25
9. Round steak	0	09	0	.09								
10. Round steak	0	.13	0	.13								
11. Round steak	0	.04	0	.04								
12. Round steak	0	.08	0	.08	0	.11	0	.11	.03	.22	0	.25
13. Round steak	0	.03	0	.03								
14. Round steak	0	.03	0	.03	0	0	0	0	.42	.24	.34	1.00
15. Knuckle soup bone	0	0	0	0	0	0	0	0	0	.16	0	.16
16. Pot roast	0	0	0	0	0	0	0	0	.23	.27	0	.50
17. Shank soup bone	0	0	0	0	0	0	0	0	0	0	0	0
18. Shank soup bone	0	0	0	0	0	0	0	0	0	0	0	0
19. Shank soup bone (hock)	0	0	0	0	0	0	0	0	0	0	0	0
Total round trimmings	0	1.96	2.28	4.24	.26	1.93	2.24	4.48	3.46	5.03	3.42	11.91

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[1] Includes loss and error.

TABLE 36.—LEAN, VISIBLE FAT, AND BONE IN TRIMMINGS FROM THE RETAIL CUTS OF THE ROUND, EXPRESSED IN PERCENT

Retail round cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Rump roast	0	29.78	70.22	100.00	4.81	31.27	62.54	98.62	35.13	29.18	35.69	100.00
2. Round steak (first cut)	0	36.00	64.00	100.00	19.67	9.84	67.21	96.72	24.59	29.51	45.90	100.00
3. Round steak	0	48.00	52.00	100.00	0	100.00	0	100.00	0	0	0	0
4. Round steak	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00
5. Round steak	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00
6. Round steak	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00
7. Round steak	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00
8. Round steak	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00
9. Round steak	0	100.00	0	100.00								
10. Round steak	0	100.00	0	100.00								
11. Round steak	0	100.00	0	100.00								
12. Round steak	0	100.00	0	100.00	0	100.00	0	100.00	12.00	88.00	0	100.00
13. Round steak	0	100.00	0	100.00								
14. Round steak	0	100.00	0	100.00	0	0	0	0	42.00	24.00	34.00	100.00
15. Knuckle soup bone	0	0	0	0	0	0	0	0	0	100.00	0	100.00
16. Pot roast	0	0	0	0	0	0	0	0	46.00	54.00	0	100.00
17. Shank soup bone	0	0	0	0	0	0	0	0	0	0	0	0
18. Shank soup bone	0	0	0	0	0	0	0	0	0	0	0	0
19. Shank soup bone (hock)	0	0	0	0	0	0	0	0	0	0	0	0
Total round trimmings	0	46.23	53.77	100.00	5.80	43.08	50.00	98.88	29.05	42.23	28.72	100.00

TABLE 37.—LEAN, VISIBLE FAT, AND BONE IN TRIMMINGS FROM THE RETAIL CUTS OF THE CHUCK, EXPRESSED IN POUNDS

Retail chuck cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Roast (5th rib)	.06	.05	.16	.27	.12	.06	.27	.47	.09	0	.12	.22
2. Chuck steak	.06	.02	.23	.31	.06	.02	.09	.17	.03	.06	.09	.18
3. Chuck steak	.01	.02	.03	.06	.09	.05	.09	.23	.02	.05	.18	.25
4. Chuck steak	.03	0	.08	.11	.05	.01	.06	.13	.01	.05	.03	.09
5. Chuck steak	.05	0	.17	.22	.06	.02	.07	.17	.05	.03	.23	.31
6. Chuck steak	.02	0	.06	.08	.06	.02	.06	.14	0	.03	.16	.19
7. Chuck steak	.06	.01	.19	.26	.04	.01	.08	.14	0	0	0	0
8. Chuck steak	.05	0	.06	.11	.05	0	.01	.06	0	.05	.22	.28
9. Chuck steak	.06	0	.06	.12	.09	.03	.19	.34	0	0	0	0
10. Pot roast	0	0	0	0	.39	.05	.48	.98	0	0	0	0
11. Pot roast	.14	.50	.62	1.26	.20	1.47	0	1.70	.66	1.69	.59	2.94
12. Pot roast	0	0	0	0	0	0	0	0	0	0	0	0
13. Stew	.72	1.59	0	2.31	0	0	0	0	0	0	0	0
14. Clod	0	0	0	0	0	0	0	0	.11	.20	0	.31
15. Neck	1.58	1.65	.51	3.74	.94	.51	.44	2.00	0	0	0	0
Total chuck trimmings	2.84	3.84	2.17	8.85	2.15	2.25	1.84	6.53	0.98	2.16	1.62	4.77

[1] Includes loss and error.

TABLE 38.—LEAN, VISIBLE FAT, AND BONE IN TRIMMINGS FROM THE RETAIL CUTS OF THE CHUCK, EXPRESSED IN PERCENT

Retail chuck cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Roast (5th rib)	22.00	18.52	59.26	100.00	25.53	12.77	57.45	95.75	40.91	0	54.55	95.46
2. Chuck steak	19.36	6.45	74.19	100.00	35.29	11.77	52.94	100.00	16.67	33.33	50.00	100.00
3. Chuck steak	16.67	33.33	50.00	100.00	39.13	21.74	39.13	100.00	8.00	20.00	72.00	100.00
4. Chuck steak	27.27	0	72.73	100.00	38.46	7.69	46.16	92.31	11.11	55.56	33.33	100.00
5. Chuck steak	22.73	0	77.27	100.00	35.29	11.77	41.18	88.24	16.13	9.68	74.19	100.00
6. Chuck steak	25.00	0	75.00	100.00	42.86	14.28	42.86	100.00	0	15.79	84.21	100.00
7. Chuck steak	23.08	3.85	73.07	100.00	28.57	7.14	57.15	92.86	0	0	0	0
8. Chuck steak	45.45	0	54.55	100.00	83.33	0	16.67	100.00	3.57	17.86	78.57	100.00
9. Chuck steak	50.00	0	50.00	100.00	26.47	8.83	55.88	91.18	0	0	0	0
10. Pot roast	0	0	0	0	39.80	5.10	48.98	93.88	0	0	0	0
11. Pot roast	11.11	39.68	49.21	100.00	11.77	86.47	0	98.24	22.45	57.48	20.07	100.00
12. Pot roast	0	0	0	0	0	0	0	0	0	0	0	0
13. Stew	31.17	68.83	0	100.00	0	0	0	0	0	0	0	0
14. Clod	0	0	0	0	0	0	0	0	35.48	64.52	0	100.00
15. Neck	42.24	44.12	13.64	100.00	47.00	25.50	22.00	99.50	0	0	0	0
Total chuck trimmings	32.09	43.39	24.52	100.00	32.93	34.45	28.20	95.58	20.55	45.28	33.96	99.79

TABLE 37.—LEAN, VISIBLE FAT, AND BONE IN TRIMMINGS FROM THE RETAIL CUTS OF THE CHUCK, EXPRESSED IN POUNDS

Retail chuck cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total[1]	Lean	Fat	Bone	Total[1]
1. Roast (5th rib)	.06	.05	.16	.27	.12	.06	.27	.47	.09	0	.12	.22
2. Chuck steak	.06	.02	.23	.31	.06	.02	.09	.17	.03	.06	.09	.18
3. Chuck steak	.01	.02	.03	.06	.09	.05	.09	.23	.02	.05	.18	.25
4. Chuck steak	.03	0	.08	.11	.05	.01	.06	.13	.01	.05	.03	.09
5. Chuck steak	.05	0	.17	.22	.06	.02	.07	.17	.05	.03	.23	.31
6. Chuck steak	.02	0	.06	.08	.06	.02	.06	.14	0	.03	.16	.19
7. Chuck steak	.06	.01	.19	.26	.04	.01	.08	.14	0	0	0	0
8. Chuck steak	.05	0	.06	.11	.05	0	.01	.06	0	.05	.22	.28
9. Chuck steak	.06	0	.06	.12	.09	.03	.19	.34	0	0	0	0
10. Pot roast	0	0	0	0	.39	.05	.48	.98	0	0	0	0
11. Pot roast	.14	.50	.62	1.26	.20	1.47	0	1.70	.66	1.69	.59	2.94
12. Pot roast	0	0	0	0	0	0	0	0	0	0	0	0
13. Stew	.72	1.59	0	2.31	0	0	0	0	0	0	0	0
14. Clod	0	0	0	0	0	0	0	0	.11	.20	0	.31
15. Neck	1.58	1.65	.51	3.74	.94	.51	.44	2.00	0	0	0	0
Total chuck trimmings	2.84	3.84	2.17	8.85	2.15	2.25	1.84	6.53	0.98	2.16	1.62	4.77

[1] Includes loss and error.

TABLE 38.—LEAN, VISIBLE FAT, AND BONE IN TRIMMINGS FROM THE RETAIL CUTS OF THE CHUCK, EXPRESSED IN PERCENT

Retail chuck cuts	Steer No. 1				Steer No. 2				Steer No. 3			
	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total	Lean	Fat	Bone	Total
1. Roast (5th rib)	22.00	18.52	59.26	100.00	25.53	12.77	57.45	95.75	40.91	0	54.55	95.46
2. Chuck steak	19.36	6.45	74.19	100.00	35.29	11.77	52.94	100.00	16.67	33.33	50.00	100.00
3. Chuck steak	16.67	33.33	50.00	100.00	39.13	21.74	39.13	100.00	8.00	20.00	72.00	100.00
4. Chuck steak	27.27	0	72.73	100.00	38.46	7.69	46.16	92.31	11.11	55.56	33.33	100.00
5. Chuck steak	22.73	0	77.27	100.00	35.29	11.77	41.18	88.24	16.13	9.68	74.19	100.00
6. Chuck steak	25.00	0	75.00	100.00	42.86	14.28	42.86	100.00	0	15.79	84.21	100.00
7. Chuck steak	23.08	3.85	73.07	100.00	28.57	7.14	57.15	92.86	0	0	0	0
8. Chuck steak	45.45	0	54.55	100.00	83.33	0	16.67	100.00	3.57	17.86	78.57	100.00
9. Chuck steak	50.00	0	50.00	100.00	26.47	8.83	55.88	91.18	0	0	0	0
10. Pot roast	0	0	0	0	39.80	5.10	48.98	93.88	0	0	0	0
11. Pot roast	11.11	39.68	49.21	100.00	11.77	86.47	0	98.24	22.45	57.48	20.07	100.00
12. Pot roast	0	0	0	0	0	0	0	0	0	0	0	0
13. Stew	31.17	68.83	0	100.00	0	0	0	0	0	0	0	0
14. Clod	0	0	0	0	0	0	0	0	35.48	64.52	0	100.00
15. Neck	42.24	44.12	13.64	100.00	47.00	25.50	22.00	99.50	0	0	0	0
Total chuck trimmings	32.09	43.39	24.52	100.00	32.93	34.45	28.20	95.58	20.55	45.28	33.96	99.79

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